ROADS AND STREETS

PUBLISHED MONTHLY BY GILLETTE PUBLISHING COMPANY

CONKEY AVE. AND MADISON ST., HAMMOND, IND., AND 221 EAST 20TH ST., CHICAGO, ILL.

Publishers of
Engineering and Contracting — Road and Street Catalog and Data Book
Municipal News and Water Works — Water Works Catalog and Data Book
Roads and Streets — General Contractors' Catalog and Data Book

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Subscription Price $2.00 — Foreign Postage 65c Extra

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LXVIII — AUGUST, 1928 — No. 8

s the Road Hog on the Narrow Road to Blame?

In 1918 there were 17 motor cars, whereas at present there are more than 40 cars per mile of improved roads. Yet we repeatedly hear it said that our road improvement programs are bordering upon extravagance. The extravagance, if any, consists in the purchase of more cars and not in the building of more good roads.

If our people, with almost unanimous voice, insist upon owning more and better motor vehicles, no clearer evidence is needed that they want more and better highways. Of our 3,000,000 miles of roads, only 78,000 are first-class thoroughfares, and less than 20 per cent of the total mileage can be said to be "improved." The well paved roads radiating from our larger cities are usually so congested on Saturdays and Sundays as to make traveling unpleasant as well as dangerous.

No single thing will do more to decrease accidents than the widening of congested highways in and near cities. A recent study of accident statistics in one of our states indicated that half the motor car accidents were attributed to "road hogging." But "road hogging" is primarily indicative of inadequate width of highway.

While there is not the slightest doubt that careless driving is the direct cause of most accidents, there is equal certainty that the careless driver can neither be driven off the highways nor educated into carefulness. The manager of a large street railway system told the writer several years ago how he had greatly reduced accidents by an analysis of accident records, followed by discharge of careless motormen. He said that nearly 90 per cent of the accidents were caused by 10 per cent of the motormen, until he instituted the policy of transferring or discharging men whose accident record was high. Then followed an amazing decrease in accidents.

Since no such control is to be had over careless drivers of motor cars, other steps must be taken to reduce the number of accidents; and the two most effective steps will be the widening of highways and the extensive use of automatic stop and go signals.

The congested two-lane road must become a four-lane road; the congested four-lane road must become a six, eight, or ten-lane boulevard.

Most of us are still not only "small-town" but buggy-minded as to our highways. We have witnessed a marvelous transformation in our road vehicles and a stupendous increase in their numbers. With a sort of stupification we have watched these changes, not realizing how much we should do to fit the highways to match the vehicles. It is true that we have talked in millions of our road bonds and gasoline taxes, but we have failed to consider the tens of millions spent for motor cars. Our public budget has not matched the private purse.

Should We Reform Our Mathematical Symbols?

The use of Greek letters could profitably be dispensed with by mathematicians, for it is exceedingly expensive to print formulas that contain these and other ancient symbols. In fact, a studied effort should be made to revise the whole system of mathematical hieroglyphics so that the linotype machine could be used in composing formulas.

As a simple illustration of the sort of change we have in mind, take the fraction 12/17. If set thus, 12/17, it becomes a simple linotype operation, and occupies one line instead of two.

Another example is the present use of numbers to indicate powers, thus, A^3, which could be revised so as to make it unnecessary to have more than the ordinary linotype characters, thus A(3). The number representing the power could be set in parenthesis. Then in order to avoid confusion it might be desirable to reintroduce into algebra the sign of multiplication; so that if we had 12 raised to the 16th power, it would be set as 12(16); whereas 12 multiplied by 16 would be set as 12×16. Remembering that the omission of the multiplication sign in algebra had as its object the saving of time, we see that its reintroduction may be economic of time when we give consideration to the linotype machine.

Illustrative again of needed changes in mathematical symbols, take the Greek letter for p ("pi"). What excuse has it for further use to designate the fraction 3.1416+, when the very same result could be secured by using an abbreviation of that fraction, thus, 3.14+? This abbreviation, it is true, is not so brief as the letter "pi," but it has the economic advantage that it can be set on any linotype machine.

Our mathematical language was evolved centuries before the linotype machine was invented, and in fact,

at a time when very little printing of any kind was done. It was, moreover, the offspring of brains trained in the use of the classic languages, which were then not dead, but only dying. Newton wrote his celebrated treatise, "Principia," in Latin. For him and other classically trained mathematicians there was no obstacle in ancient symbols and words. But although it is otherwise now, we still cling to an uneconomic symbolism.

We talk of the need of simplifying our spelling by making it more nearly phonetic, yet we make snail-slow progress toward that goal. Probably a reformer of mathematical symbols would meet with equally discouraging slowness in the acceptance of a more economic plan, for custom generally outpulls reasoned conclusions—at least for a long while. Witness the vain attempt to reform Chinese symbols by the introduction of an alphabet. Chinese ignorance and industrial backwardness is largely attributable to the inability of most Chinamen to read, or, reading, to possess such scientific and engineering books and magazines as we have. Consider the cost of setting up and printing one copy of this magazine in Chinese symbols. Then bear in mind that it could be read by only a minute fraction of the Chinese. And, finally, ponder the power of custom over common sense—that most uncommon mental attribute, commonsense.

H. P. Gillette

Major Recommendations of Model Municipal Traffic Ordinance

Eight major recommendations for a model Municipal Traffic Ordinance will be continued in a model code which will be submitted this month to more than 3,000 municipalities, to aid in the handling of their problems of street congestion and traffic, according to the Traffic Committee of the American Motorists' Association, one of the national motoring organizations working on the model traffic code plan. The code was prepared by the Committee on Municipal Traffic Ordinances and Regulations of the National Conference on Street and Highway Safety, of which Secretary of Commerce Herbert Hoover is Chairman.

The eight major recommendations for the model code are as follows:

The pedestrian, at an intersection, shall always have the right-of-way. Between intersections, the motorist shall always have the right-of-way, the effect of these two regulations being to stigmatize jaywalking and to yield to the pedestrian the unquestioned supremacy at intersections.

The practice of a motorist passing a street car on the left is condemned except where it is a one-way street or where the track is placed on the extreme right hand side of the highway.

The right-of-way rule between motorists at intersections is further clarified, as follows: The motorist on the right shall always have the right-of-way unless the vehicle on the left first enters the intersection, in which event the vehicle on the left shall proceed and clear the intersection with due regard for safety.

For cities installing traffic control signals the Conference was of the consensus, and so voted, that the three color system, including green, yellow and red, is the most efficient.

More stringent ordinances against the blocking of highways and streets, by railroads, was declared to be paramount due to the increasing density of traffic.

Motorists at all times, should be prevented by an ordinance, from driving through a clearly marked pedestrian safety zone.

The loading or unloading of commercial vehicles where the process requires more than 30 minutes, should be permitted only at night, thus minimizing traffic congestion.

Cruising of taxicabs should be forbidden and in lieu of that practice all cities should authorize designated taxicab stands at convenient points.

As the result of the three-day conference which resulted in the adoption of the code, it was the consensus of opinion that pedestrian control is not desirable but that rather a close observation of traffic regulations by pedestrians is what is needed. As the result of the observations, made by officials from large cities, it was voted not to include pedestrian control in the model Municipal Traffic Ordinance. Figures submitted by them showed that in many instances, on busy corners if pedestrians were controlled by traffic lights that the congestion would be so dense that it would not give sufficient time to enable pedestrians to cross the street before the signals were against them.

Need for a model Municipal Traffic Ordinance was evidenced from figures submitted to the Conference showing that at the present time the annual death rate is approximately 26,000 per year. The model code, it was estimated, would result in the saving annually of a large percentage of this annual death toll. Total deaths from street and highway accidents during the past 15 years, was placed at 196,800, according to figures submitted to the conferees.

Break-Down Costs

An engineer on a touring trip stopped to watch the progress of work on No. 20 Michigan State Highway. While he was there a large mixer broke down. The seat of the trouble was found in a magneto that had suddenly gone out of commission. The contractor had no emergency unit on hand and the only solution was to put the magneto on a 5-ton Mack truck and haul it 18 miles to a repair shop, with the mixer operator attending.

The repair sation had no porcelain, which is seldom stocked, and they had to send for porcelain parts. It finally took 2½ hours for repairs—resulting in a labor cost plus the cost of parts. During this time the job was tied up, affecting at least 20 men on this one unit.

Here was a break-down that resulted in the following costs:

2½ hours @ $1.50 per hour (for labor on repairs)	$ 3.75
Platinum points	7.50
Porcelain	1.00
Remagnetizing	1.00
Total repairing cost	$13.25
Truck and driver job, 4 hours	8.00
Helper or operator @ 70c per hour	2.80
20 men idle @ 60c per hour	48.00
Total cost of break-down	$72.05

Had this contractor an emergency unit on hand he would have saved money on this break-down cost—let alone the time element which was valuable in the contract. Contractors carrying an emergency unit can be assured of constant operation—or units for all their equipment powered with gas engines.

How this idea can be expressed in a form of service: The auxiliary unit can be put in a box with lid screwed on. In case of emergency, this unit can be immediately taken out, installed and the one out of commission can be put in the box, lid screwed on and sent to the maintenance department or repair shop.

Incidents of this kind are a common occurrence in the contracting field—costing the contractor time and money—valuable elements in relation to his profits.

It seems that such an emergency service would be a logical solution to this problem. Premature break-downs loose time, and lost time eats profits.

New County Engineers Organization

County officials representing each of the 55 countries of West Virginia assembled in Huntington on June 29 and 30, and formed a state association of county officials. The new organization will receive the complete cooperation of the County Officials Division of the American Road Builders' Association.

C. N. Conner, Executive Engineer of the American Road Builders' Association, was present at the session and assisted in the organization work. The purposes of the new group will be to study the problems peculiar to county road work in West Virginia, thereby eventually creating standards which will be conducive to the most efficient and economical promulgation of county work.

The new organization is the third to be formed within the past three months, the others being Delaware and Tennessee.

Investigation of Foundations in Highway Bridge Surveys

Five Most Commonly Used Methods of Exploration

By C. B. McCullough
Bridge Engineer, Oregon Highway Commission

FOUNDATIONS may be explored by several methods. The five most commonly used are (1) sounding rod, (2) soil auger or boring machine, (3) wash boring or churn drilling, (4) core drilling, and (5) test pits.

Method Depends Upon Conditions.—The method to be used in any particular investigation will depend upon the conditions encountered, the size and importance of the project, its accessibility, available equipment, and other factors. In general detailed instructions regarding each individual project will be issued from the central office and equipment for the particular job will be assembled and shipped from headquarters. The field engineer, however, should be familiar with the general principles involved in the various methods of foundation exploration. When equipment is to be shipped to the job from headquarters, the recommendations from the field engineer will, to a certain extent, determine the type of equipment selected. The field engineer should be qualified to proceed on his own initiative in the absence of detailed instructions. He should be sufficiently familiar with general equipment requirements to enable him to look over any drilling or boring equipment available locally and to pass upon its adequacy. Many times he will be called upon to visit well-drilling outfits, going over their equipment and advising the office as to the desirability of contracting the drilling work. He should be able to judge as to the relative merits of different outfits and also as to the advisability of contracting at a price per lineal foot or renting the outfit on a per diem basis.

Many times, especially for small jobs, it is not feasible to rent or contract a well-drilling outfit and the cost of shipment for an assembled plant is prohibitive. The field engineer may be forced to assemble an outfit with the material and equipment which he can pick up locally.

The paragraphs which follow present a brief description of the five methods of exploration. The treatment is by no means complete as even a brief description of the various types of drills and drilling apparatus in common use would fill a volume in itself. For more complete description of the various types of drills and the various methods employed for drilling, their limitations and scope, the engineer should consult available published reports, records, and text books on the subject. The manufacturers of core and churn drills put out very complete and comprehensive literature in which may be found complete descriptions of the various drilling processes and types of apparatus commonly used.

Fig. 1.—Wash-Boring Outfit Mounted Upon Truck With Light Steel Leads for Drop Hammer Used for Driving Casing

Sounding-Rod Exploration

Process.—The process consists simply in driving, churning, or otherwise forcing a sounding rod through penetrable strata to determine the elevation of any solid strata below. The bar is worked or churned down as far as it will go, using water to lubricate the hole if necessary, and then driven down the balance of the way, using either a hand maul or rammer. If possible, the driving is continued until the bar strikes solid material.

Equipment.—The equipment needed may generally be purchased locally and consists essentially of the following items:

Solid round bar (or heavy pipe), ¾ to ⅞ in. in diameter, threaded for standard coupling at upper end and pointed for driving at the lower end. This bar is for the lower section and should be from 6 to 12 ft. long.

Additional sections of pipe or rod from 4 to 6 ft. long. These sections should be threaded for standard coupling at both ends.

The upper section of rod should be fitted with a drive cap. This drive cap may be fitted with a suitable wooden cushion if desired. If advisable, a short drive section (2 to 4 ft. long) may be used either with or without a drive cap. This section is taken off as additional sections are added and placed on top of the last added section.

Heavy maul or rammer with vertical handle to be used for driving rod.

An ordinary pipe wrench to turn rod.

A lever and chain or other suitable device to pull rod or pipe.

If the strata is such that the rod must be driven from the start, the first section should not be over 6 ft. long in order to avoid the necessity of building an elevated driving platform.

Precautions Regarding Operation.—All rods should enter couplings for the full length, so that adjacent rod sections about to make close contact and severe driving will not strip the threads. Where driving is exceptionally difficult, extra heavy or hydraulic couplings should be used. These can generally be purchased locally. Hydraulic couplings are longer and stronger than standard couplings and are cut with a perfect taper and longer threads. Couplings known as recessed couplings may generally be obtained. This coupling projects beyond the limits of the pipe thread, thus protecting the pipe at its weakest point.

All soundings should continue until the rod "brings up." If the rod "brings up" with a sharp ring, it probably rests on rock or a large boulder. If the rod "brings up" with a dull ring or if repeated driving causes it to break through for a short additional penetration, the material is probably stiff gravel. Indications of solid rock should be checked by several other tests a few feet distant to guard against mistaking a heavy boulder for solid bed rock.

All rod sections should be cut to even lengths and each section numbered and recorded in a note book prepared for that purpose, so that at any time the exact position of the point of the rod may be determined without the necessity of withdrawing the rod and measuring.

Soil-Auger Exploration

Process.—Boring with a soil auger is usually done by hand, but horse-power and gas-power outfits (for well-boring operations on a large scale) are on the market. The hand auger is made to bore into the soil by turning levers or wrenches fastened to the stem. This method may be employed for any material which will adhere to the bit such as loam, clay or clayey sand, or gravel. For shallow borings through material not too wet an ordinary post auger may be employed. For deeper holes, when hand power is used, the auger bit is generally from 1½ to 2½ in. in diameter. Where the material penetrated will not stand without support, a pipe or well casing is placed.

The auger is first used to penetrate the soil as far as possible and is then withdrawn and the casing is driven or churned down as described later under wash boring.

Several kinds of casing are used for this class of work. The cheapest is a light sheet-iron pipe riveted together very much like stovepipe. It can not be used where it is necessary to force or drive the casing. It is easily injured in handling and is not to be recommended except for temporary casement of comparatively large and shallow holes. Other types are known as well casing (which is considerably lighter than ordinary standard pipe), ordinary black pipe, and "drive pipe" or extra heavy pipe employed for churn or wash borings where the driving is exceptionally difficult or the holes are very deep.

Several types of joints are used for the different types of casing. For well casing, the socket coupling, the inserted joint and the flush joint are most commonly used. The socket coupling is the only one suitable to withstand heavy driving. The socket coupling is generally employed with ordinary black or steam pipe (flush-joint drive pipe is sometimes used) while for drive pipe, extra heavy or hydraulic couplings are generally used. Drive pipe ends should be cut square to furnish an effective bearing against each other within couplings. Other types of joints or couplings are on the market but the above types are the most commonly used.

A shoe or cutting edge must be provided where casing is to be driven and there must also be a drive head at the top, as will be described in more detail under wash borings. The size of the casing should be sufficient to afford clearance for the auger bit.

The type of casings or couplings selected will depend upon the resistance of the strata. In general, time will be saved by adopting a heavier type of casing than perhaps is necessary, even at a slightly increased cost rather than run the risk of delays owing to failure of light casing to withstand driving.

As soon as a casing has been worked and driven down as far as it will go, the auger is reinserted and the hole cleaned out to the bottom of the casing and as much further as it is possible to go without caving. The process of driving and cleaning is then repeated until the desired depth is obtained or a solid strata is encountered.

Equipment.—The following equipment is needed:

Soil auger.

Pipe casing where needed.

A tripod or stiff-leg derrick with suitable block and tackle for pulling auger bit and casing.

A ram or drop hammer for driving casing (see wash borings).

Necessary pipe fittings and small tools (see wash borings).

A bailer or sand pump when needed (see wash borings).

A water jet outfit when needed (see next paragraph).

Precautions Regarding Operations.—The auger stem should be of substantial construction as it may twist off, particularly when the boring is through clayey gravel containing large pebbles. Each section of auger extension and each section of casing should be cut to an even length and numbered. The numbers and lengths should be recorded in a notebook in order to determine readily the depth penetrated. If the material is such that it will not come up on the auger bit, the hole may be cleaned by means of a bailer or sand pump. The bailer device is a piece of pipe with a valve inserted in its lower end. This bailer is lowered through the casing and churned up and down until full. If in bailing out the hole the material is not fluid enough to pass through the valve of the bailer, or sand pump, water is added to facilitate the operation. If the sand pump or bailer will not work, a water jet may be employed to clean out the hole. If a water-pressure line is not available, a suitable force pump must be secured to supply the water jet.

When bowlders are encountered, they may be drilled through with a hard rock churn drill or drilled and shot as described under wash borings.

Soil-auger explorations are sometimes made with a horsepower rotary well-boring machine. These machines are in more or less common use in some sections of the country and may be obtained at reasonable cost to do foundation-exploration work. In one of the commonly used machines, a horse is hitched to the platform lever and operates the auger bit directly. When the auger is filled, the operator engages the hoisting clutch and the continued motion of the horse raises the auger stem. When the bit has been raised to the platform, a small crane is used for swinging the auger out upon the bank for emptying.

This type of machine will bore holes

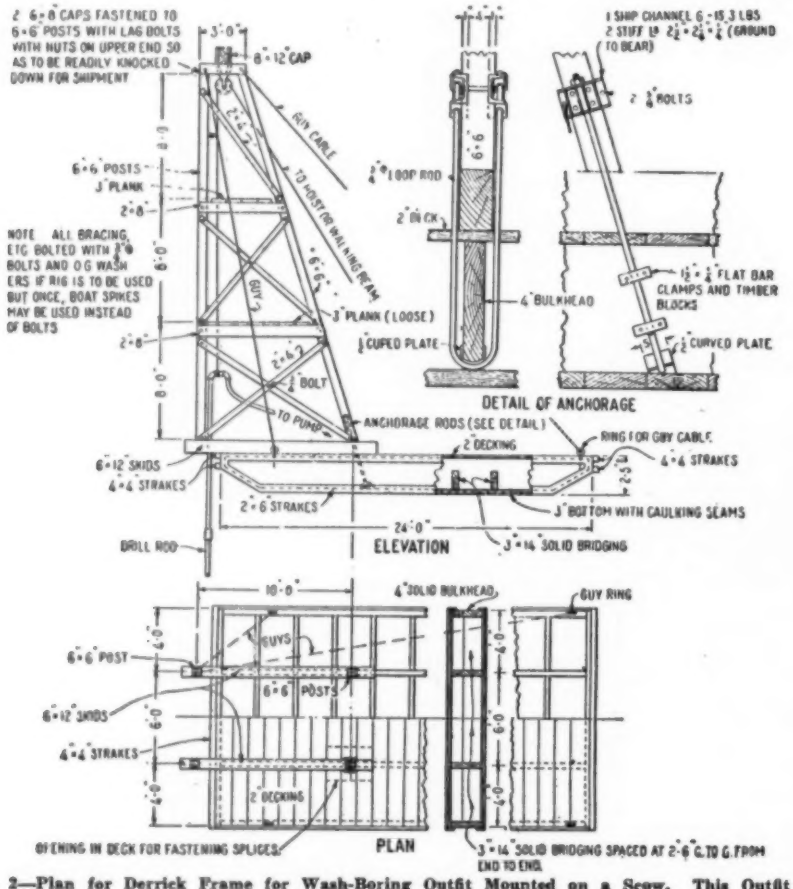

2 6"×6" CAPS FASTENED TO 6"×6" POSTS WITH LAG BOLTS WITH NUTS ON UPPER END SO AS TO BE READILY KNOCKED DOWN FOR SHIPMENT
8"×12" CAP
RUN CABLE
TO HOIST FOR WALKING BEAM
6"×6" POSTS
3" PLANK
NOTE ALL BRACING, ETC BOLTED WITH ⅞" Ø BOLTS AND O G WASHERS IF RIG IS TO BE USED BUT ONCE, BOAT SPIKES MAY BE USED INSTEAD OF BOLTS
GUY
3" PLANK (LOOSE)
BOLT
TO PUMP
6"×12" SKIDS
4"×4" STRAKES
2"×6" STRAKES
DRILL ROD
ELEVATION
1 SHP CHANNEL 6"-15.3 LBS
2 STIFF LP 2½"×2½"×½" (GROUND TO BEAR)
¾" LOOP ROD
4" BULKHEAD
½"×4" FLAT BAR CLAMPS AND TIMBER BLOCKS
½" CURVED PLATE
DETAIL OF ANCHORAGE
ANCHORAGE RODS (SEE DETAIL)
RING FOR GUY CABLE
2" DECKING
3" BOTTOM WITH CAULKING SEAMS
3"×14" SOLID BRIDGING
4" SOLID BULKHEAD
GUY RING
GUYS
6"×6" POST
6"×6" POSTS
6"×12" SKIDS
4"×4" STRAKES
2" DECKING
OPENING IN DECK FOR FASTENING SPLICES
PLAN
3"×14" SOLID BRIDGING SPACED AT 2'-6" C. TO C. FROM END TO END

Fig. 2—Plan for Derrick Frame for Wash-Boring Outfit Mounted on a Scow. This Outfit Is Designed for Knocking Down for Shipment

from 6 to 24 in. in diameter and usually to a sufficient depth. Further details of operation and equipment, such as underreamers for enlargement of the hole for casing, may be obtained from the manufacturers' catalogues.

The companies manufacturing this type of equipment also make a complete boring and drilling machine operating a churn drill with jars and sand pumps. These machines are also arranged for gasoline power.

Wash Borings

Process.—The term "wash boring" is used to describe the operation of churn drilling with a hollow drill pipe having on the lower end a cutting bit through which a stream of water is forced to wash the cuttings to the surface.

The type of bit used depends upon the nature of the material. For cutting through clay and light gravel, a chisel-faced bit is used, while a chopping bit or fluted rock bit is generally used through boulders, sandstone, or other solid material. The drill bits are pierced with small openings cut so as to direct the water jet against the sides of the hole. Water under pressure (either from city supply or a force pump) is forced down the hollow drill rod and through the bit openings. The hole is drilled by churning the drill up and down turning it at each stroke. The hole is started or "spudded in" either by hand or by means of a mechanical device.

When a hole has been churned down as far as it will go without danger of caving, the drill is withdrawn and casing is driven as described under soil-auger operation. From this point on, the operation is one of alternately drilling and driving casing and the equipment should be so arranged as to make it possible to change from one operation to the other with a minimum of time loss.

Equipment.—Drilling outfits of this kind are generally to be assembled and shipped from the headquarters office if available and the shipping cost is not prohibitive. Sometimes it is possible to secure equipment on a rental basis. If neither of these can be done, it is necessary to purchase and assemble equipment on the ground.

The equipment needed will vary to a certain extent with the particular job, and where it is assembled on the ground it is necessary to utilize such material as is readily at hand. With this is mind, the equipment list which follows has been made rather general, being simply a brief statement of the essential requirements, leaving the details to be worked out by the field engineer.

1. A truck, barge or platform upon which to mount the plant. Figure 1 shows a truck-mounted outfit of a type satisfactory for land operation (in the figure it is shown working in about 18 in. of water). For land operation, the outfit can be mounted upon a timber platform or skid frame or it can be used without mounting of any kind. For water operation, the outfit should be mounted upon a barge or upon pile platforms. Figure 2 shows a plan for a barge of a type which has proven satisfactory. Two small barges fastened together by a plank platform with the drill operating through the opening between them, have been used with good results. These small barges should be at least 6 to 8 ft. wide and 20 to 25 ft. long. All barges should be provided with suitable anchors and

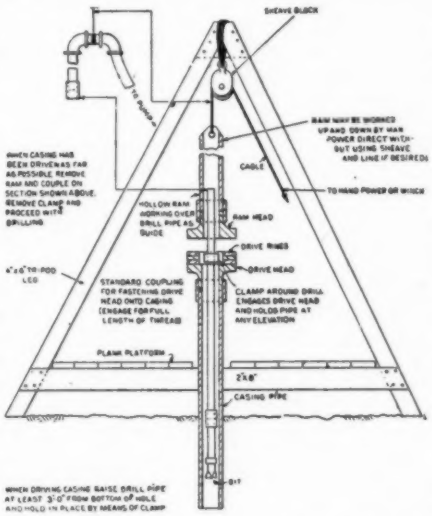


Fig. 3—Tripod for Hand-Operated Wash Drill

anchor lines. Concrete blocks may be used for anchors.

2. A derrick, frame, or tripod for supporting the drill rod and water line (Figs. 2 and 3).

3. A suitable force pump for supplying water under pressure if a city or other supply is not available. The pump should be fitted with a discharge connection for ¾ or 1 in. hose and with 15 to 20 ft. of suction hose with foot valve and strainer.

4. Device for spudding or churning drill. This may be done by hand, lifting the drill rod several inches and churning it down again, or mechanically. The mechanical devices most frequently employed are either the walking beam, horizontal drum and "niggerhead" line, horizontal drum to which drill-rod line is fastened and which is thrown in and out of gear by means of a lever clutch, or a cam or eccentric.

The walking-beam device is probably the most frequently used, especially with commercially assembled drilling outfits.

When a horizontal drum is used the drill rod and bit are hoisted a few feet and released for a free drop by slacking off on the niggerhead line or releasing the lever clutch. The cam or eccentric device imparts a churning motion to the drill in somewhat the same manner as the walking beam. There are a number of other devices which have been used and others which may suggest themselves to the field engineer who is assembling equipment in the field. Any device which will impart a churning motion to the drill without an excessive consumption of power and without restricting its free fall and which is not too expensive or complicated for practical use will be satisfactory. The height of drop necessary will depend upon the character of the material and varies from 6 to 36 in.

5. Suitable power equipment for the spudding device, water pump, lifting the drill rods, and to operate the hammer line in case a drop hammer is used for driving the casing. For the small drilling outfits commonly assembled in the field, a two to five horse-power engine will probably be sufficient.

6. Device for driving casing. The casing may be driven by means of a ram or weight operated by hand, as shown in Figure 3, with an ordinary hand maul, or by the use of a drop hammer. Figure 1 shows a set of light steel leads for use with a gravity hammer. The hammer line is wound on the horizontal drum shown in the rear of the truck and released for a free fall of the hammer by disengaging a clutch.

With some drilling outfits the ram is cored out to fit over the drill rod which acts as a guide for the ram. With this arrangement casing may be driven without pulling the drill pipe clear up. This arrangement saves much time where there must be frequent alternation between drilling and driving casing, to prevent the casing from "freezing" in the hole.

7. Suitable drill rods and bits. The drill rods should be made up in sections of even lengths of from 5 to 10 ft., each section of rod being numbered and its exact length recorded. For ordinary work, 1-inch standard black pipe may be used for drill rods. For difficult boring or where the depth exceeds 75 to 100 feet, extra heavy pipe should be used. Standard outside pipe couplings may be used in ordinary cases, but extra heavy or hydraulic couplings are better, if available. Recessed couplings, if available, are to be preferred for reasons already discussed.

In drilling to a considerable depth it often happens that conditions are encountered which make it necessary to use smaller size casing in the lower part of the hole. If the outside couplings on the drill rod will not clear the smaller casing it is necessary to change to smaller drill rods or use flush couplings. The ordinary flush-joint coupling is not as strong as the outside coupling and will not stand heavy usage. Extra heavy flush couplings are generally obtainable and should be used if a flush-type joint is employed.

Drill bits should be of special alloy or of hardened steel. In general a chisel-edge bit is used for clay, loam, and gravel, while a cross chopping bit (two chisel edges at right angles) or a fluted rock bit is employed for heavy

gravel, boulders, or rock. Drills for wash borings should be perforated by apertures for the water jet, the perforations being so bored that the jet is thrown against the sides of the hole. Chisel bits may be made locally, if necessary, by inserting a solid stub into the lower end of the drill pipe, then forging out to correct shape and hardening.

8. Casing pipe. A description of the various types of casing ordinarily employed has been given under the discussion of auger borings.

Well casing is generally rather light for wash-boring work. The threads on this type of casing are finer and the shell thickness considerably less so that it will not stand driving to the same extent as standard black pipe or steam pipe. The cost of well casing is about two-thirds of that for standard black pipe and about one-half that of extra heavy pipe, so that for material through which casing can be "turned down" or seated with very light driving, this type of casing will show distinct economy. For ordinary conditions, however, standard black pipe with ordinary standard outside couplings should be used. Extra heavy pipe or "drive" pipe should be used for all heavy driving and for all holes exceeding 75 to 100 ft. in depth. The drive pipe should be cut square and should butt squarely at the center of the coupling. Hydraulic couplings (preferably recessed couplings) should be used for heavy casing. These can generally be obtained in sizes up to 4 in. which covers all couplings ordinarily used. Casings should be fitted with a drive section having a cutting edge around its entire perimeter and also with a special drive head. For very heavy driving it may be necessary to use a timber shock block over the drive head. For ordinary work 2½-in. casing is used. For deep or difficult work it is generally advisable to start with 3-in. casing as it may be necessary to use a smaller casing telescoped inside the first. Where the ground to be penetrated is soft and casings may be worked or churned through, rather than driven, flush-type couplings will reduce side friction.

In purchasing casing material the engineer should keep in mind the salvage value. For example, standard galvanized-iron pipe is used for well casings, and if only one set of borings it to be made it may be economical to purchase this type of casing, as it will have a much more ready resale and a higher value than black pipe.

9. Suitable hose connection. For connecting the water hose to the drill rod, a suitable water swivel should be obtained, if possible. If a water swivel is not obtainable the hose may be connected direct to the drill pipe with an ordinary hose connection, a standard coupling, and a return bend.

10. Fifty to 100 ft. of rubber hose.

11. Chain block and set of screw jacks.

12. Supply of pipe fittings for casing and drill pipe, including standard couplings, flush-type couplings (if available), elbows, tees, bends, bushings, etc.

13. Small tools — pipe cutters, wrenches, pipe tongs, stocks and dies, a pipe vise, rope and tackle, pipe clamp and set of wedges, hammers, saws, shovels, etc.

Precautions Regarding Operation.— The hole should be started without casing if possible, washing down until caving starts or until the bit starts to stick or jam. Work or churn the casing down as far as possible before starting to drive.

If it is possible to keep the bit ahead of the casing pipe, the pipe will follow down plumb, the bit tending to "lead" the pipe down, but if driving is necessary the casing may easily become deflected from a vertical position by a bowlder or rock and may cause difficulty later. Driving should not be resorted to until absolutely necessary, but the casing churned or worked down, following the bit at as great distance as possible. When it becomes necessary to start driving the casing, the drill rod must be pulled up from the bottom of the casing for a distance of at least 3 or 4 ft.; otherwise material will work up from the bottom around the drill point and cause it to jam.

Casing should be driven comparatively short distances at a time and driven frequently in order to avoid "freezing" in the hole.

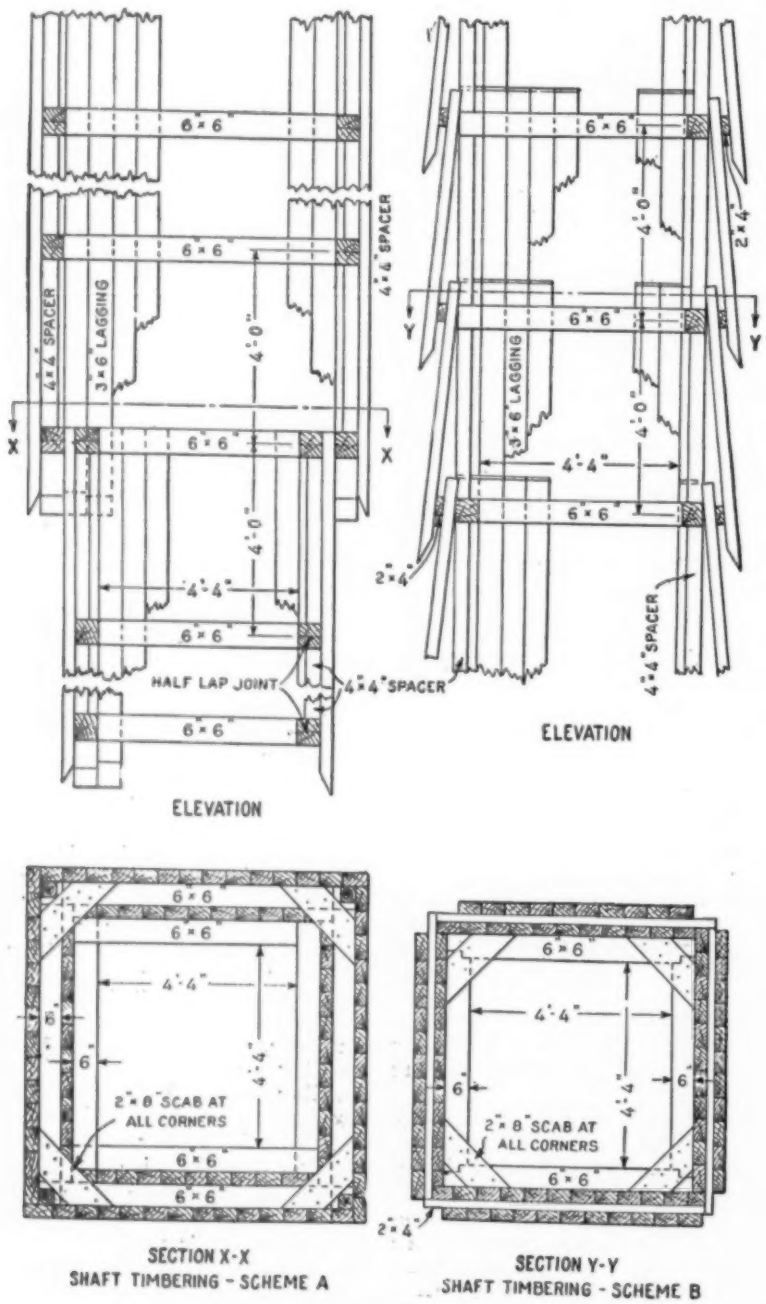


Fig. 4—Two Methods of Timbering Large Test Pits

Every joint on the drill pipe and on the casing should have sufficient thread to fully enter the couplings. For heavy driving the end of the pipe should be cut square to furnish a butt joint in close contact around the entire perimeter of the pipe; otherwise, the driving is quite apt to strip the threads.

The size of casing used must be such as to give free clearance for drill rods, and prevent binding. If, on the other hand, too much clearance is left between the drill rod and casing, the volume of water necessary to wash cuttings to the surface will be so great as to require larger pumping equipment than would otherwise be necessary. For ordinary work drill rods of 1-in. pipe, using ordinary outside couplings, either standard or hydraulic, may be used with 2½-in. standard pipe casings.

Care must be taken not to drill too far ahead of the casing or the bit is likely to become jammed in the hole and broken off in pulling.

When the casing will not penetrate further and the desired depth has not been obtained, it becomes necessary to underream or to drive a small casing inside the first one. If smaller sized casing is used, the original size drill rod should be worked down as far as possible ahead of the casing. This drill rod is then withdrawn and the small casing driven as far as possible. From this point on, a drill rod having a smaller over-all dimension, must be used on account of the decreased size of the second casing. This clearance may be obtained by shifting to a smaller size drill pipe or using a flush-type coupling.

The hammer or ram employed for driving the casing should preferably be arranged to work over the drill rod to eliminate the necessity for withdrawing the drill rod while driving casing.

Where driving is exceptionally difficult and for holes deeper than 75 ft., extra heavy pipe, with hydraulic recessed couplings, should be used for a casing.

If the casing becomes jammed in the hole and will not penetrate further, it may be pulled for 3 or 4 ft. and the uncased hole "sprung" with a charge of a half of three-fourths of a stick of 40 per cent dynamite.

When the drill is stopped, the pump should be kept running until the overflow water is clear of washings, and the bit raised a few feet or the drill may stick in the bottom.

When solid rock is reached, drilling should be continued for several feet to make certain that the strata is sufficiently thick to distribute the load of the structure. Solid rock should be penetrated 3 or 4 ft. and shale 6 to 12 ft.

As soon as hole is down and all data are secured, the casing should be pulled. This may be done with either a chain block and pipe clamps, block and tackle and pipe clamps (using a multipart line), lever and chain, or screw jacks and pipe clamps. If it is impossible to pull the casing, break it below the lowest coupling with a stick of 40 per cent dynamite. This will allow salvaging all but the lower section of casing.

Be sure that all barges or platforms in navigable streams, and all work adjacent to highways or railways, are suitably protected at night by red-lanterns.

Dry-Churn Drilling

This type of drill sometimes known as the cable drill, and used in the oil fields, consists of a heavy bit, drill stem and a set of jars fastened to a cable by means of a rope socket. An up and down or churning motion is imparted to the cable by means of a cam or walking beam. The bottom of the hole is kept filled with water. The material in the hole is chopped and ground up by the drill bit and removed by means of a sand pump or bailer. The spudding bit is used for cutting through clay or loose stone. The paddle bit is used for seamy and fissured rock and the fluted rock bit is used for other rock formations. The paddle bit is of special construction and is not used as much as the other two. The drill cable passes over an idler pulley at the top of the derrick leads and down over another idler fastened to the walking beam and thence over the cable drum. Jars are used as a safeguard against the drill becominng jammed in the mud or in crevices in the rock, or to prevent a newly dressed bit from wedging. The slack motion in the links is about 6 in. with this type of equipment and the weight of the jars for 5⅝-in. hole is about 200 lb.

During the first proecss of drilling, or what is known as "spudding in," the drill is fed into the hole by means of the cable drum on the rear of the machine. For greater depths, the cable is removed and fastened to what is known as a temper screw, suspended from the yoke of the walking beam, which allows a more closely regulated feed. The cable is generally of hawser laid manilla rope.

With this type of drill, the casing can be driven by using the string of drill tools as a hammer or ram. Driving clamps are clamped on the drill stem and engage a drive cap screwed on the casing. The walking beam can be made to deliver up to 60 strokes per minute, causing the string of tools to deliver a series of rapid blows to the casing. These rapid blows from a comparatively heavy weight falling through a short distance are very effective in tapping down the casing pipe.

In drilling with this type of equipment, a method known as drilling on the spring of the cable is employed. At a depth of 50 ft. when the drill tools are at the lowest point of their stroke, the point of the bit should be adjusted to hang about 2 or 3 in. from the bottom of the hole. At 100 feet this distance is adjusted to 4 or 5 in., with greater distances for increased depth. The downward stroke of the drill will spring the cable an amount sufficient to let the bit strike a practically uncushioned blow. The advantage is that at the upper limit of the up stroke the drill tools lag behind the walking beam, so that on the down stroke the entire weight has a free gravity fall.

After the material is chopped and ground the hole is cleaned out by means of bailers or sand pumps. The principal difference between this type of drilling and wash boring is the method of transporting the cuttings to the surface. This type of drill may be used for any foundation-exploration work to which the churn drill is adapted. The general principles regarding the selection and driving of casing pipe apply in work of this kind as well as in the case of wash borings.

Core Samples

Percussion Core Drills and Cylindrical Cutters.—Core samples are necessary if an examination of the material in its natural and undisturbed condition is desired. A device which will cut core samples at various depths is therefore an essential part of churn-drilling and wash-boring equipment.

One device is known as a percussion core drill and is adapted to coring any reasonably soft material, such as soft sandstone, coal, or fire clay. This device extracts the core without the use of wash water. When a core is desired the cable tools are withdrawn and the drill bit and stem removed, leaving the jars and rope socket in place. The percussion core drill is joined to the jars, the tools lowered into the hole, and the drilling resumed at a moderate speed. Two core barrels are provided so that when the first core has been cut the tools can be raised and the core barrels exchanged. A core extractor is used to remove the core.

Often a core cutter is rigged up from materials at hand for use with wash-boring, churn-drilling, or auger-boring outfits. A piece of pipe with the edge at one end sharpened and the other end arranged so that it can be attached in place of the cutting bit will do for the purpose. The core cutter is worked into the material until it is filled with a sample. For material whose resistance is so great as to preclude the use of driven cylindrical cutters or percussion drills, rotary core drills must be employed.

Rotary Core Drills.—The process consists in the cutting out of a solid core of the material by means of a cylindrical cutter to which is imparted a rotary motion. There are three types of core drills commonly used, known as the diamond drill, the diamondless or shot drill, and the saw-tooth drill or core cutter.

Diamond Drills.—The diamond drill consists of a soft steel, hollow cylinder with black diamonds or carbons set in

the edge and which act as the abrasive. The cylinder is fastened to a hollow vertical stem, which is rotated by means of suitable gearing to an engine or other power unit. As the drill is rotated a water jet is fed to the bit to cool it and to wash the cuttings to the surface. Diamond-drill outfits are generally fitted with an automatic device for feeding the bit into the rock and a derrick or tripod for operating and raising the bit, and a pump for supplying the water pressure. Diamond drilling is rather expensive work, owing to the high cost of equipment and the loss of diamonds during operation. The cost of diamonds for one drill bit ranges from $800 to $1,200. Different rock formations require resetting of diamonds in order to cut with maximum efficiency and to avoid as far as possible the loss of diamonds, and this requires the presence of an experienced diamond setter on the job at all times.

Diamond drills are especially adapted for boring into rock or other solid material. Where hard material is overlain by soft strata a hole is generally washed down or churned down and cased into the rock before core drilling commences. It is necessary to drive the casing well into the rock and to wash it clean in order to avoid the possibility of sand or loam entering the bore hole and working around the drill. Foundation exploration with diamond drills is generally either by contract at a price per foot or on a per diem rental basis under the supervision of an experienced operator, and the field engineer will rarely be called upon to supervise diamond-drill operations.

Diamondless Core Drills.—The diamondless core drill or shot drill consists of a circular steel core bit generally with a notch cut out in its lower edge. Chilled steel shot or a crushed steel abrasive are fed under the edge of this bit. These shot are fed through a pipe from the top of the hole. The shot drill can be used for the same purposes as the diamond drill, except the drilling of holes inclined at an angle greater than approximately 45 deg. with the vertical, which rarely occurs in foundation exploration. The use of shot as an abrasive is many times cheaper than diamonds, and this type of drill does not require the services of a high-priced diamond setter, and if a bit is lost no great financial outlay is wasted. When diamond drilling is employed it is generally necessary to have two bits for each drill in order to keep the machine in operation should it be necessary to reset the diamonds.

It happens frequently with both types of drills that a bit and core are lost. With a shot drill this does not necessarily mean the loss of the hole, as a new drill may be inserted and the hole continued, cutting through the original bit. On account of the low first cost of the shot bit, as compared with the diamond bit, it is economically possible to secure a much larger core. Diamond bits are generally limited in size to 2 or 3 in., whereas it is possible to cut cores up to 20 in. in diameter or even larger with the shot bit. One of the advantages of the shot drill is that cores of different diameters may be drilled with the same machine without extra equipment, other than an extra core barrel and cutter; whereas the diamond drill generally requires an entirely different set of tools and drill rods.

The value of core records depends to a certain extent upon the successful extraction of the material without injury or change of character. Cores can be taken with a shot drill of a much larger diameter than is possible with the diamond bit on account of the prohibitive cost of the diamond drill. Larger cores, except in the most resistant material, remain intact to a much greater extent than small ones. With the shot drill, cores 4 or 5 in. in diameter may be extracted nearly as cheaply as cores 1 or 2 in. in diameter, so that cores entirely adequate for foundation exploration may be obtained with slight additional cost.

Operation of Shot Drill.—One commonly used type of shot drill operates as follows: Power applied to the drill rod a the surface rotates the latter with the receptacle for cuttings, core barrel, and bit or cutter. Water is pumped through the hollow drill rods and into the core barrel. As the bit rotates it cuts a circular groove in the material under it. The water passes from the core barrel, under the bit, and up through the annular space left around the core barrel by the clearance on the bit, the stream carrying with it the cuttings. This water rises at high velocity until the top of the receptacle is reached, where its velocity is greatly reduced because of the larger passage afforded around the drill rod. The heavier cuttings carried by the water, therefore, have a chance to settle at this point, falling into the receptacle on top of the core-barrel plug. With a little experience the flow water can be adjusted to remove the cuttings without lifting the shot. As the bit penetrates, a cylinder or core of the material drilled rises through the hollow bit into the core barrel. When the core barrel has been filled for nearly its full length the core is broken off, and is hoisted to the surface with the string of tools. With this type of apparatus there is always a clean surface for the bit or cutter to work upon and the tools do not stick or jam due to cuttings settling around them.

The shot for the shot drill are fed into the drill through the water swivel at the top of the drill rod. One type of swivel has two connections, the larger one being for the wash water and the smaller one for feeding the shot.

For soft materials a saw-tooth or chisel-tooth rotary cutter is sometimes used.

Lifting Cores.—The diamond drill has a special device which clamps the cores, thus enabling them to be lifted, but with the shot drill the core is generally lifted by washing sand or grout into the hole to jam the core in the core barrel. When it is desired to lift a core, rotation is stopped and the flow of the water increased in order to wash out the hole around the bit. Small gravel or sand is then introduced and pumped to the bottom of the hole. This sand lodges inside the bit between the core and the inner walls of the bit, where it is wedged by the water pressure around the core. The core is then broken loose by a few sharp twists of the rod and lifted to the surface. In soft and friable formations likely to disintegrate under drilling a tool known as a double-core barrel is sometimes used.

Core drilling is generally done by contract or with rented equipment, for which experienced operators are available. The following brief suggestions, however, may be of value should the field engineer be called upon to directly supervise core drilling:

When mud seams or fissures are encountered there will result in the loss of water, and in shot drilling the loss of shot. If the condition is serious, the hole may have to be cased through the mud seam or fissure. Either the hole must be reamed for a casing which will be large enough to clear the drill bit or else a smaller drill must be used for the remainder of the hole.

When drilling through soft or caving rock care must be exercised to avoid sticking or jamming the bit, as this may result in the loss of the tools. With the shot drill, when the tools are lost, it may be possible to redrill with a new bit cutting hrough the original bit. In some cases it may be necessary to either abandon the hole entirely or else ream and ease down to the jammed bit.

In shot drilling the stream of water must be carefully regulated. If the water pressure is too strong the shot are washed away from the cutting edge; if not strong enough the cuttings will not be removed.

Before withdrawing a drill and core wash out the hole with a strong jet of water, or the bit is very apt to jam.

Where a core must be made fast to the bit by washing down sand or grout to jam the core in the barrel considerable care must be exercised to avoid dropping the core.

Special Light Drilling Outfits.—A light outfit is now on the market to meet the demand for a portable drilling rig, readily set up and moved from hole to hole and also comparatively cheap in first cost. This outfit is especially designed for rapid and cheap

drilling. It consists of a small gasoline engine driving a force pump to furnish a water jet for washing down the hole, casing, drill tubes, cutting shoes, and small tools. The casing is 2⅝ in. in diameter and is of special high-carbon, cold-drawn, seamless tubing upset and thickened on each end for a special square thread and flush-joint connection. It is heat treated after finishing. The drill tubing is 1⅛ in. in diameter. Both casing and drill tubing come in 4-ft. lengths.

The casing is fitted with a cutting shoe at its lower end and the drill bit and casing are washed and churned down by hand, as described under wash borings, the gasoline-driven force pump furnishing the water supply. When it becomes necessary to drive the casing a special drive cap is fitted and the driving is done with a heavy maul. When the hole is finished the casing is pulled by means of chain tongs and jacks.

The net weight of this outfit, including sufficient casing and tubing for a 50-ft. hole, is about 800 lb. This type of rig may be used for work where the magnitude does not warrant a more extensive layout for test borings.

The outfit may also be equipped with a core-drill rig operated by means of a water motor which, in turn, is driven by the gasoline-operated force pump. The core-drilling tools weigh approximately 350 lb.

Test Pits

Excavation of a large pit or hole and examination of the material in place is the most reliable but by far the most costly method of foundation exploration. In stiff material and shallow pits no sheeting is necessary; in soft material and for all holes in excess of 10 or 12 ft. in depth bracing, shoring, and perhaps solid sheeting are needed. The size of the pit must be sufficient to permit access for inspection. In general 2½ by 2½ ft. is about the minimum size.

Excavation may be done by means of shovel and platform, hoist bucket and tripod, or a small orange peel or clamshell bucket.

Fig. 4 illustrates two different methods of shoring or bracing test pits through soft material. Where semisolid material is penetrated horizontal or vertical plank braced between opposite sides of the pit by means of shores or trench jacks may be employed. The method employed and equipment needed will obviously vary with the individual case.

Acknowledgment.—The foregoing is extracted from a Technical Bulletin by Mr. McCullough in cooperation with the U. S. Bureau of Public Roads, issued recently by the U. S. Department of Agriculture.

Concrete Road Construction During Freezing Weather

Some interesting information on the above subject was given by M. B. Hodges, Resident Engineer, Texas State Highway Department, in a paper presented at the 4th (1928) annual short course in highway engineering at College Station, Tex. The note following is taken from his paper.

There has been some discussion concerning the matter of pouring concrete during the winter months. Some contractors shut their plants down during these months, stating that because of the many days that they will be idle, it does not pay them to hold their organization through the winter. Our specifications state that no concrete shall be placed during freezing weather nor under 36° F. without the permission of the engineer. It has been found that concrete can be poured during cold weather if the proper care is taken for the protection of the pavement. But due to the short hours allowed for working and the danger of losing what has been placed, very little of this work is done in the northern or north-central portion of the state. In the southern part of the state, however, pavements are placed practically throughout the winter months and with very little delay. The past winter has been an exceptionally mild one. Only twelve days were lost in Freestone County on account of cold weather. While the work did not progress very rapidly on account of the short days and the few hours allowed for work, yet an average of about one and three-quarter miles per month was laid during the winter months. In the controlling of work during cold weather hourly readings of the thermometer are taken during the day. If, during the morning, the temperature is rising, work may be started after the thermometer passes 32° F. A careful watch of the thermometer is kept during the day and when the temperature begins dropping, work is discontinued at about 40° F. If, late in the afternoon or evening, the thermometer falls down to 32° F., the pavement is covered with burlap which, in turn, is covered with earth, or fires are built on each side of the pavement and kept up throughout the night. Either method will probably prevent the freezing of the concrete. The first method is objectionable because, as a rule the pavement sets very slowly on account of its low temperature and the placing of burlap and covering with earth will scar the pavement very much unless care is taken to prevent the shoveling of large clods of earth upon the burlap.

There still exists some doubt as to the harmful effect of freezing concrete. It is generally believed that injury to concrete is not caused by one freezing, but by alternate thawing and freezing. In other words, concrete may freeze during the night after having been placed but if properly taken care of during the following day, no damage will result. This belief was borne out during the past winter with a test cylinder that had been frozen. Work was stopped one afternoon about four o'clock and fires were kept along the sides of the pavement during the night. The temperature dropped to about 24° F. during the course of the night. The following morning the cylinder made just before work was stopped was found to have frozen. It had been placed under the north fence line and did not receive any of the protection afforded the pavement by the fires. The cylinder was then buried in wet sand for about three days and then cured in the usual manner in water. This cylinder developed just as high compressive strength as did others that had not frozen.

The Important Quart?

When you fill a gallon measure, which is the more important quart, the first or the last?

Filling a gallon measure and the building of roads are two widely different operations, and yet the above question appearing in these columns indicates that we think they may have something in common. And that something, to our minds, is the importance of the items in the making up of a bid on road work compared to the quarts used in filling a gallon measure.

We do not believe that anyone will question the importance of any particular quart used in the filling of a gallon measure. We know, however, that many items going into the cost of road building are questioned as to their relative importance by some contratcors. Depreciation, overhead, traveling expenses, surety bonds, unforeseen contingencies, fuel, oil, gas, grease, and many other items that enter into the cost of constructing the work, are just as important as labor, and materials which, we believe, some few contractors seem to consider the most important items of cost.

No job can be done without every item being a part of that job. No profit can be made unless all of these costs are a part of the estimate, so we feel absolutely safe in our view that every item in the cost of building roads is just as important as every quart used in filling a gallon measure. And we also believe that if every contractor would give the same importance to every item of cost in building a road as is given to each quart used in filling a gallon measure, there would be fewer failures and better prices in the road construction industry.—Public Construction News.

Construction Features of a Zion-Mt. Carmel Road

A road involving unusual construction difficulties is now being built in the Zion National Park. This road, when completed, will very materially shorten the present highway distances. Something of the ruggedness of this section of the country can be guessed when it is known that the little town of Bryce is about 54 miles from this project as the crow flies—but is 159 miles by highway. Cedar Breaks is only about 30 miles to the north, as the bee would travel, but as motorists must travel it is 140 miles distant. This new cut-off, which scales the 90 degree side of a canyon, reduces the 159 miles to Bryce to 88 miles and to only 70 miles to Cedar Breaks. Because of this new road the Grand Canyon, which lies to the south (now about 142 miles by road) will be brought closer by nearly 40 miles.

The Nevada Contracting Co. has the contract. The company is using more than 250 men in the work, and right now is "driving hole'" (for a goodly portion of the road is a tunnel) at the rate of 900 ft. a month. This tunnel, driven through rock, is 22 ft. by 14 ft. in dimensions, with six gallery portals scattered along the way, which afford stopping places where the automobilist may draw aside from the traffic and view the stupendous scenery. Some of these galleries are 75 ft. or more in length, and the arch of their portals is 35 ft. high.

The roadway tunnel itself is a trifle more than one mile in length, and comprises Section No. 2 of the Zion-Mount Carmel Road. Section No. 1, also under contract to the Nevada Contracting Co., is about four miles long and most of this length is spent in "making elevation" as the engineers say, up the talus slope at the foot of the cliffs which form the canyon's perpendicular sides and scenic features.

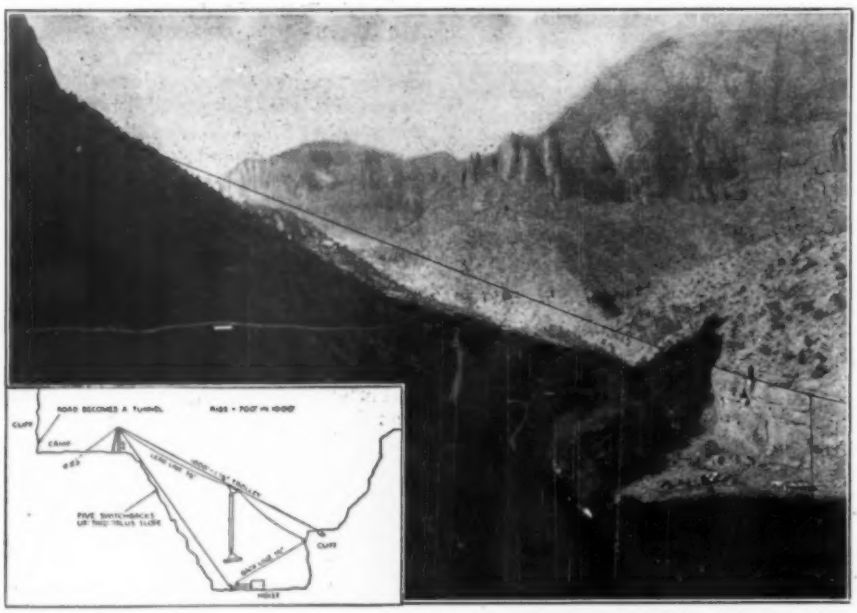
A Glimpse of the Scenery to Be Viewed from One of the Galleries of the Zion-Mount Carmel Road

Some idea of where Section No. 2 begins and leaves off, and where Section No. 1 starts is given by the accompanying photographic reproduction and line drawing, the latter of which was furnished by the superintendent on the job. In the photograph may be seen the temporary camp, down in the depths of the canyon,—the talus slope up which the road being built switch-backs its long 4 mile way to the foot of the cliff. At this point (the top of the talus slope and the foot of the cliff) Section No. 2, or the tunnel, starts. At this point, however, even switch-backs become unavailing, with the result that the road necessarily becomes a tunnel. It being unnecessary to bore through the bowels of the cliff, the road follows its face, and so it is that for light and ventilation, for the purpose of giving the workmen all outdoors in which to dump their yardage, and also to provide motorists with an opportunity to view the unparalleled scenery, portals have been broken out of the sides and galleries provided.

All the necessary machinery, such as drills, compressors, transformers, shovls, etc., necessarily had to be transported to the job through the canyon itself and landed at the foot of the talus slope. These, then, were hoisted to the foot of the cliff by means of a 1,000 ft. aerial cableway—a 700 ft. rise in 1,000 ft. The wire rope employed here was the American Cable Co.'s Tru-Lay rope, the sizes being given in the line drawing. A 40 ft. tower was erected at the top of the slope to permit the cableway to operate and to land the machinery properly.

An unexpected and unwanted test of the durability of this preformed cableway rope was experienced when hoisting a 3,000 lb. compressor base. At the time this base was being hoisted and the load was in mid-air, the attachment that shackled the wire rope to the tower in some way failed and permitted the wire rope bearing its heavy load to split the tower from top to bottom. The compressor base was not seriously damaged and the rope was not fractured, with the result that both compressor and the same cable have been in full operation for some time.

To dig the tunnel along the face of the cliff it was necessary to erect scaffolding —in some cases from the top of the talus slope, in others suspended from the top of the cliff. From this scaffolding the several portals or gallery openings were broken out by hand until the holes became large enough to permit the employment of Butler mine shovels, these being operated by compressed air. The compressors for this work were furnished by the Sullivan Machinery Co., the electric power being transmitted by a specially built line 20 miles long.



A View of the Talus Slope up Which the Zion-Mount Carmel Road Switch-Backs Its Way to the Foot of the Cliff, Where It Becomes a Tunnel. Note the Aerial Cableway Stretched Across the Canyon. The Line Drawing Shows, in Principle, the Arrangement of This Aerial Tram

Methods of Resurfacing With Emulsified Asphalt Penetration Macadam in European Countries

Notes on the Practice in England, France and Germany

By C. L. McKESSON

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MOST of the highways in the European countries have been macadamized for many years. These existing macadam surfaces are frequently utilized without the addition of metal by the simple expedient of surface treatment with emulsified asphalt or tar, but where the road surfaces are more or less irregular or worn the reconstruction practice usually takes the form of penetration macadam resurfacing.

Construction Methods Similar to Ours.—Penetration macadam resurfacing is, in general, constructed in accordance with the approved practices with which we are familiar. Emulsified asphalt has, however, become quite popular in this type of work instead of the ordinary hot asphalt or road oil, and this popularity may be attributed to the ease with which the material can be applied even in unfavorable weather, to the simplicity of the equipment, as well as to the very satisfactory work which has been thus produced. Interesting examples of this work were found in England, France, and Germany. The following descriptions of work as conducted in these countries will show the striking similarity to penetration macadam as we have constructed it in this country, but will also bring out some differences of practice which are made practicable by the difference in form of the bituminous material used.

It should be borne in mind in this connection, that emulsified asphalt is simply a standard asphalt which has been made liquid by the addition of water and a very small amount of emulsifying agent and that, when the emulsion breaks down, the water leaves the road and the asphalt remains in the form of a thin layer over the rock particles. Emulsified asphalt roads at this stage do not differ from roads constructed thinner and there is a marked absence of displacement sometimes noted where excessive amounts of bitumen have been used in hot penetration work. There is also an entire absence of "bleeding" and the texture which results is usually of a type which could be classified as non-skid due, probably, to the thinness of the coating on the rock particles and to the absence of excessive richness in the surface of the road.

Penetration Resurface Over Old Macadam.—Figure 1 is a view of work under way on Leighton-Hockliffe Road, in Bedfordshire, England. This work consists of a penetration resurface over an old tar treated macadam surface. The inspection was made on a damp, misty day and the depressions in the old road surface were filled with water as is shown in the illustration. This, however, did not deter the construction forces. Mr. Mann, the Division Engineer in charge, stated that they had no difficulty in working in this kind of weather and, as there is considerable rainy weather in England, the ability to use emulsified asphalt under this condition is one of its valuable qualities. The engineers accustomed to using it, however, do not recommend carrying on work of this kind during freezing weather.

Figures 2 and 3 are other views of the resurfacing work in the Leighton-Hockliffe Road. Due to the fact that this road is a heavily traveled main highway it was necessary to construct a macadam resurface on one side of the road at a time, allowing traffic to use the other half of the road. In constructing the macadam resurface a very thin layer of sand was first distributed over the old tar macadam. The engineer explained that this was to intercept the emulsified asphalt which penetrates the rock surface and to prevent it from running out to the shoulders. The next stage is to spread a uniform layer of crushed stone which passes a screen having 2 in. circular openings and which is retained on a screen having 1¼ in. circular openings. This material is spread by hand and is rolled lightly with a 10 ton roller to bring out irregularities in the surface. These irregularities are carefully corrected by loosening up and adding more stone where required or by removing stone. After the surface is smooth and uniform a light covering of stone chips was distributed over the surface, as shown in the photo, and swept into the rock. This, the engineer explained, was done to prevent the liquid emulsion from running through the metal too quickly. A comparatively small amount of chips was used at this stage and the voids only partially filled. Excessive rolling at this stage is carefully avoided; the purpose of the rolling being merely to develop irregularities so that they can be corrected.

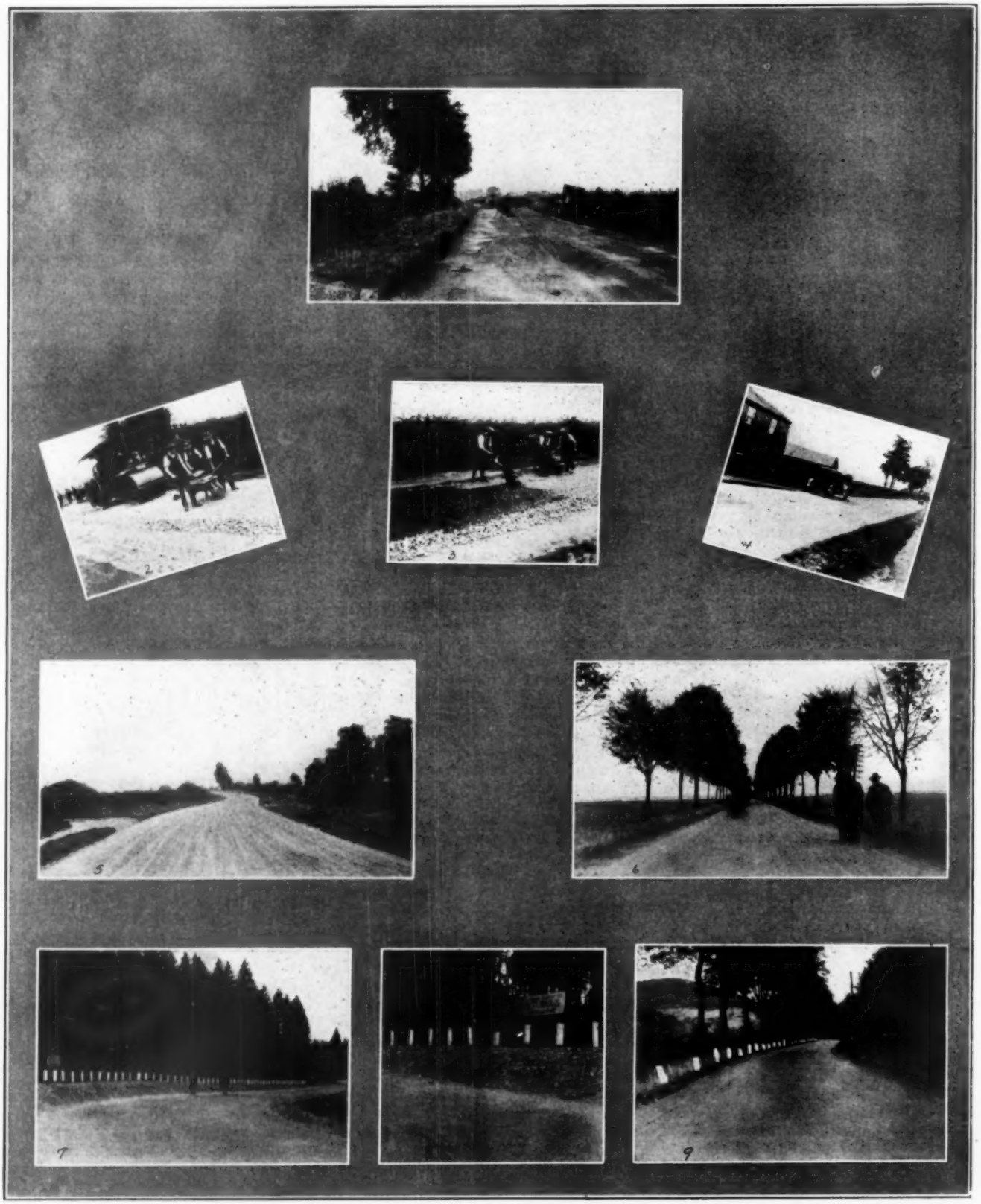
The emulsified asphalt for this work was shipped to the job in metal barrels and applied with hand pouring-pots. The emulsified asphalt pours readily from the barrel and is distributed with remarkable uniformity with the pouring-pots. The first application consisted of 1.64 (U. S.) gal. After this application stone chips were distributed over the surface and swept in until the voids are entirely filled; rolling continuing during this operation. After the surface is thoroughly compacted and filled a seal coat was applied in similar manner using .41 gal. of emulsified asphalt per square yard. This was followed with a cover coat of chips and again rolled.

Figure 4 is a section of this road finished in the same manner several weeks before the inspection. It will be noted that this macadam resurface which is 2½ in. to 3 in. finished thickness used slightly more than 2 gal. per square yard of emulsified asphalt. The emulsion was made from Grade "E" 200 penetration asphalt and contained approximately equal parts of asphalt and water. The actual amount of asphalt used in the road is, therefore, about 1 gal. per square yard. This is about one-half the amount of hot asphalt that would ordinarily be used in this country in a penetration macadam of the same thickness. Inasmuch as the road was well bound and apparently well sealed it is apparent that this result must be made possible by reason of thinner coatings on the particles. The actual amount of bitumen used is apparently about 3 per cent of the weight of the road metal, which is estimated to be about 270 lb. per square yard. This would correspond quite closely with the amount of bitumen which would be used for the same grading in hot plant mixed work.

Figure 5 is a view of another Bedfordshire road with emulsified asphalt penetration surface.

A German Resurface Job.—Figure 6 is a view of the main international road between Neuss and Aachen, Germany. This highway was surfaced many years ago with waterbound macadam over a Telford base. In November, 1926 a 2 in. resurface was constructed in much the same manner as the Bedfordshire resurfacing already described. The first course of stone was from 1¼ in. to 2 in. in size. This was filled with ⅜ in. to ¾ in. screenings, rolled and then given a first application of 0.88 gal. per square yard

of emulsified asphalt. After screening and rolling a second application of 0.44 gal. per square yard of emulsified asphalt was applied. The second application was covered with stone chips from 10 mesh to ¼ in. and a seal coat of 0.22 gal. per square yard of emulsion was applied. This, in turn, was covered with a light coating of the same chips. The



Penetration Macadam Construction in England, France and Germany

(1) Leighton-Hockliffe Road in Bedfordshire, England, (2) Macadam Resurface Construction Over One-half of Road, (5) Applying Emulsified Asphalt, (4) Completed Section of Road, (5) Emulsified Asphalt Penetration Surface on Bedfordshire Road, (6) Main International Road Between Neuss and Aachen, Germany, (7) Penetration Macadam on Nurburg Ring in the Eifel Mountains, Germany, (8) Texture of Pavement on Nurburg Ring. Fig. 9.—Penetration Macadam on Highway Between Bonn and Trier, Germany

emulsified asphalt was applied by hand as in the Bedfordshire work. Stone paving-blocks were laid along the edge prior to resurfacing and the resurfacing finished flush with the tops of these header blocks. The resurfacing has a fine texture somewhat resembling Topeka pavement due to the fineness of the stone chips used for covering. It was stated that 60 per cent of this work was done during the rain.

This main highway is in a thriving industrial center and carries a very heavy volume of truck and passenger traffic. There was no evidence of rolling, corrugating, or other displacement and the surfacing appeared to be meeting all traffic requirements.

Penetration Macadam on German Race Course.—Figure 7 shows an emulsified asphalt penetration macadam surface on the Nurburg Ring in the Eifel Mountains, Germany. This is a section of mountain race course 20 miles in length built for use in international auto races. In the construction of this race course the German engineers built sections with each of the types of surfacing most commonly used in Germany for the purpose of studying relative value of the types. The sections included emulsified asphalt penetration, emulsified tar penetration, Tar-Mac, cement concrete, and Essner natural asphalt. The surface, in general, consists of a Telford base about 8 in. in thickness and a macadam surface about 4 in. thick. The section shown in the illustration has a surface consisting of rock from ¾ in. to 1¼ in. in size in sufficient quantity to form a penetration macadam of 2 in. compacted thickness. From 1.3 to 1.5 gal. of emulsified asphalt was applied per squarel yard in three applications with ¼ in. to ⅝ in. stone chips between. On this section the sub-soil is a heavy clay and some difficulty was experienced due to the clay coming up into the macadam. It was necessary to scarify and reroll some of the macadam base before the treatment, and in a few places water was coming from the subgrade through the pavement and surface and running to the sides of the roadway. In spite of this unfavorable condition the road was found to be reasonably smooth and without any breaks or evidence of repairs. There were short sections of grade up to 17 per cent. Figure 8 shows the texture of the pavement.

Penetration Macadam in a Military Road.—Figure 9 is a view taken at Rossburg on the highway Bonn to Trier, Germany. This is a military road built by Napoleon. Early in 1926 a macadam surface was constructed consisting of a basalt with sand for filler 3½ in. to 4 in. in thickness. This, in turn, was covered with 1¼ in. to 2 in. crushed basalt sufficient to form a wearing surface about 2¾ in. in thickness. The wearing surface received a treatment of about 1.25 gal. per square yard of emulsified asphalt, was covered with stone chips and thoroughly rolled. One year later the road received an additional 0.22 gal. of emulsified asphalt per square yard and additional stone chips. The road surface was found to be smooth and uniform with a good non-skid texture. It is on a grade ranging from 5 per cent to 7 per cent. The cost of this bituminous macadam surface was given by the engineer as 75 ct. per square yard. Emulsified asphalt brings $35.00 to $40.00 per ton in this locality. Labor costs are about one-half those in the United States.

Penetration Macadam Over Old Stone-Block Pavement.—On National Route 20 at Chevilly, France a penetration macadam surface has been constructed over an old stone-block pavement. The surface consisted of ¾ in. to 1½ in. rock spread to a thickness of 2 in. and rolled. The stone chips, ⅜ in. to ⅝ in. in size, were distributed over the course of stone and rolled in. 1.4 gal. per square yard of emulsified asphalt was applied in one application and given a light cover of stone chippings. Rolling was continued until the road was thoroughly compacted. Three weeks after, the surface was washed and the roadway received a seal coat of 0.33 gal. per square yard of emulsified asphalt and another cover of stone chips. It was not rolled after this seal coat. The cost of this surfacing was 60 ct. per square yard.

Acknowledgment.—The matter above is taken from a paper presented by Mr. McKesson at a meeting of the Western Association of State Highway Officials.

Federal Aid Road Construction

Two hundred nineteen million three hundred and seventy five thousand dollars worth of good roads will be the Federal government's contribution to the cause of national progress during the next three years, according to the American Road Builders' Association. The sum to be allocated to each state under the Federal Aid road appropriation was made public by the association.

A total of $73,125,000 will be available to the states and Hawaii during each of the years 1929, 1930, 1931. The states must spend a minimum of $198,049,992 on the Federal Aid roads during the three years in order to take advantage of their Federal appropriation.

"The annual contribution of the Federal government constitutes less than 7 per cent of the cost of road construction and maintenance each year in the United States," the American Road Builders' Association declared. "It is less than five hundredths of one cent for each mile travelled by motor vehicles during 1928.

"The association asserted that good roads are a national as well as a local asset, and that the Federal government should not only make its periodic appropriations perennial, but should increase them beyond the present limitations. The nation still has in excess of 2,000,000 miles of unimproved roads, much of which is in need of improvement."

The allocation of Federal funds for 1929, 1930 and 1931 road construction in the United States and Hawaii, has been made by the United States Bureau of Public Roads. There may be a few minor corrections in the apportionments for 1930 and 1931 as a result of mileage revisions. With the exception of 13 states in which more than 5 per cent of all land is non-taxable, the states must finance at least 50 per cent of Federal Aid road costs, and in no case will the government contribute in excess of $15,000 per mile.

The apportionment to each state and Hawaii, and the minimum which may be expended on the same roads by the states, for each of the years 1929, 1930, 1931, is as follows:

State	Federal Apportionment	Minimum State Share
Alabama	$ 1,547,483	$ 1,547,483
Arizona	1,059,081	404,951
Arkansas	1,281,785	1,281,785
California	2,486,415	1,893,659
Colorado	1,383,401	1,083,484
Connecticut	474,213	474,213
Delaware	365,625	365,625
Florida	901,311	901,311
Georgia	1,980,015	1,980,015
Hawaii	365,625	365,625
Idaho	932,962	628,481
Illinois	3,135,225	3,135,225
Indiana	1,921,463	1,921,463
Iowa	2,035,291	2,035,291
Kansas	2,062,196	2,062,196
Kentucky	1,421,029	1,421,029
Louisiana	1,019,282	1,019,282
Maine	681,431	681,431
Maryland	634,906	634,908
Massachusetts	1,088,808	1,088,808
Michigan	2,209,596	2,209,596
Minnesota	2,112,595	2,112,595
Mississippi	1,309,729	1,309,729
Missouri	2,404,347	2,404,347
Montana	1,552,576	1,199,064
Nebraska	1,584,981	1,584,981
Nevada	957,995	134,115
New Hampshire	365,625	365,625
New Jersey	935,122	936,122
New Mexico	1,189,361	685,715
New York	3,629,879	3,629,879
North Carolina	1,715,910	1,715,910
North Dakota	1,193,440	1,193,440
Ohio	2,757,964	2,757,964
Oklahoma	1,749,066	1,405,815
Oregon	1,189,707	1,404,109
Pennsylvania	3,333,786	3,333,786
Rhode Island	365,625	365,625
South Carolina	1,059,533	1,059,533
South Dakota	1,223,981	976,632
Tennessee	1,612,012	1,612,012
Texas	4,502,576	4,502,576
Utah	848,093	226,803
Vermont	365,625	365,625
Virginia	1,437,548	1,437,548
Washington	1,143,226	962,152
West Virginia	793,796	793,796
Wisconsin	1,864,212	1,864,212
Wyoming	939,547	524,068
Totals	$73,125,000	$66,016,664

Road Construction in Panama Forecasted.—The early commencement and active prosecution of road construction work by the government between Santiago de Veraguas, the present western terminus of the National highway system, 165 miles from Panama City, to David in the Province of Chiriqui, is forecasted.

Jacking a Culvert Through a Rock Ledge

During last fall two 24-in. and one 36-in. Armco corrugated pipe culverts were installed by the jacking method on Parkersburg-Charleston Road about 14 miles south of Parkersburg, W. Va. On one of these jobs rock was encountered, necessitating drilling and blasting. The work was done by a maintenance crew and is described in the June issue of the Highway Magazine by A. W. Paine, Division Maintenance Engineer, West Virginia State Road Commission. The notes following are taken from the above mentioned publication.

Equipment and Materials for Jacking.—The equipment and materials used for jacking the two 24-in. culverts included:

Ratchet screw jack, 75-ton.
Small mattock with short handle for digging inside of pipe.
Small shovel, like trench shovel.
Short crow bar.
Wrecking bar, 24-in.
Single snatch block with hook (to fasten to top of pipe at front end).
Wooden sled, 15x24x6 in. deep.
Lining timber, 8x14 in. by 24 ft.
Post, 8x9 in. by 9 ft., for backstop.
Brace for post, 8x9 in. by 14 ft.
Block to support jack, 12x12.
Blocking, several pieces 6x6, 2 to 8 ft. long, to transmit jack pressure.
Square portal frame of 3x6-in. timbers with 3x6 cross piece to jack against.
120 ft. of ½-in. rope.

All of the above equipment was used also for jacking the 36-in. pipe. The wooden sled was improved for the latter installation by placing it on casters and providing a plank runway in the bottom of the pipe. In addition, the following power equipment was added to provide for the unforeseen material encountered and to speed up the work:

90 cu. ft. belt-driven Novo compressor with a Ford generator attached.

Jack hammer with short lengths of ⅞-in. drill.

6-volt. battery and 6-volt light bulbs, connected with good grade of insulated wire.

The Ford generator, with a small friction wheel, was so attached to the compressor that it operated on the pulley of the compressor unit and supplied lights for the workmen inside the pipe.

Jacking Method.—The Armco jacking method, as most engineers now know, consists essentially of forcing corrugated pipe underground or through an embankment by means of one or more horizontal jacks braced against a suitable backstop. The pipe does not cut its way, but follows as a shield, men excavating a short distance ahead and hauling the spoil out through the pipe.

The first step was to excavate into the slope of the fill to provide a face 4 or 5 ft. high to work against and a trench along which to jack the pipe. The line of each culvert was staked out with a transit and sighting stakes were set on the lower side to aid in locating the pipe when jacking was started. Levels were run, an accurate cross-section obtained, and grades were set.

The next step was to locate the lining timber accurately and nail 2x4 strips on either side to guide the pipe while being jacked. Care in guiding the first section proved warranted, as each line of pipe came out at the upper end with but little deviation from the computed location.

On each of the jobs, jacking was started from the lower side. Jacking uphill had the advantage of permitting the excavated material to be removed by gravity and, in one case, of preventing the pipe from being flooded during a rain.

The backstop post was firmly set and braced, the jack, portal frame and blocking put in position, and the first section of pipe rolled on the lining trough. The face of the fill was then undercut from 1 to 2 ft. and jacking begun. Only one man could work inside the 24-in. pipe. With the tools mentioned above he excavated just ahead of the pipe and placed the material in the sled. Men outside pulled the sled out by the rope, and by means of the snatch block attached to the inner end of the pipe, pulled it back in again.

Sufficient light and air were available from the old culverts so the man inside had no difficulty in working. Two men alternated working inside the pipe, having to change off frequently due to the cramped position in which they worked. The broken tile had been pressed so tightly into the embankment that its removal probably took at least as much time as would have been required for the removal of a full face of earth.

The excavation was carried to exact grade at the bottom of the pipe, but clearances of 1 in. at the sides, and 2 in. at the top, were provided to prevent the pipe from becoming squeezed. The limits of excavation were carefully checked to avoid running off of line during jacking. Troughs 6 in. wide and same depth were dug at 3-ft. intervals below the bottom of the pipe to catch loose material dragged forward by the corrugations.

One of the 24-in. lines started to dip after it had been jacked about 30 ft., and to correct this tendency a wedge shaped board was placed under the front ends of the pipe while jacking. This board was removed without difficulty and moved forward at each resetting of the jack and answered its purpose satisfactorily.

Rainy weather was encountered while jacking the 36-in. pipe and a canopy was erected to protect the men working inside. The canopy extended from the face of the cut out over the jack.

Work on the three culverts was started Sept. 20 and completed Oct. 10. Because of the lateness of the season, work was continued night and day on the 36-in. pipe. Only daylight shifts were worked on the 24-in. culverts.

Rock Drilling Necessary.—After advancing about 10 ft. with the 36-in. pipe, an 18-in. face of solid rock was encountered and then the air compressor was started. Part of the rock was soft enough to be broken with the chipping hammer; but the remainder had to be drilled and shot. Two men worked inside, as one man could not operate the drill successfully. After each shot, compressed air was used to clear out the fumes. The air hose was used also while the men were inside digging, to renew the air which otherwise became hot and foul.

The success and safety with which blasting was accomplished was gratifying because it established the jacking method as a useful means of installing pipe through almost any kind of solid material. Picric acid was used instead of dynamite. There might have been some damaging effects from using dynamite, as it is probably a little faster than picric acid. Too, noxious fumes of dynamite would be harder to remove in a reasonable length of time, even with the air hose. Picric acid comes in 1-lb. sticks, and from ½ to ¾ stick was used in each hole.

For each shot two holes were drilled into the rock about 18 in., parallel to a vertical plane through the center line of the pipe and sloping down at an angle of between 15 and 18°. At the same time the clay was removed by hand from over the rock. The holes were charged and the acid detonated by means of the 6-volt battery. From two to three sets of holes had to be shot in this fashion in order to remove the rock and permit jacking, as the holes had to be loaded very lightly.

No damage was done to the pipe or the fill by the shooting.

Costs.—The following table gives comparative data on the three jobs:

	Culvert No. 1	Culvert No. 2	Culvert No. 3
Diameter	24 in.	24 in.	36 in.
Length jacked	60 ft.	60 ft.	60 ft.
Total length	72 ft.	60 ft.	74 ft.
Material encountered	Clay	Clay	Clay and Rock
Average depth of fill	12 ft.	14 ft.	20 ft.
Days to install	6	4	10 (double shift)
Number men used	4	3	4 each shift
Estimated cost by open trench	$316	$552	$789
Total cost by jacking	130	66	435
Estimated saving	186	286	354

The total cost of the three jobs was $631, or approximately 44 per cent of the $1,457 estimated as the cost of trenching through. The cost of installing included labor, rental of the compressor and air hammers, and gas, oil, and other supplies, as well as the pipe itself. The trenching estimate did not include the costly item of replacing the pavement and maintaining the resulting bad spot, nor the cost of maintaining a detour.

How the Banker Views the Contractor

Address at Annual Meeting Indiana Highway Contractors

By C. O. HOLMES
President, Indiana State Bankers Association

I AM not Noah, nor am I a contractor, but the first large loss I ever took in my business experience was in backing a public works contractor who had no money, no equipment and experience chiefly as a boss of a bunch of mule skinners. The $5,000 I paid for that came hard, but was of great value to me ever since. In fact, it was a third of all my then earthly possessions.

Public works contracting, whether local, county or state, is suffering much as is the banking business and it is to your credit and an encouraging sign that you are alert as to the causes therefor.

The Ever Changing List of Bidders.—When I look over the names of the bidders year in and year out on state, or other highway contracts, I see new names every year in almost every list and I daresay in six years your mortality must have been 50 per cent as against our 10 per cent. Ours has been a disgrace and strain, but yours is indicative not only of failure to clean your own house somewhat but of a total failure on the part of public officials to have a sound public policy on choosing contractors.

One reason is, many, perhaps most of you, do not know your costs.

Our bankers do not know contractors' costs. Until they do, we'll have bank competition, cut-throat and ruinous, just like it's been in Indianapolis, Kokomo and elsewhere, worse in Iowa and the Dakotas, all, as in your case, at public expense.

Standard Questionnaires Commended.—When contractors know their costs—and let me pause here to commend the statement form adopted (Standard Questionnaire), even though, it is as a prominent banker has said, complicated. Use it yourself. Urge every contractor to fill out this form. Keep a carbon copy for your files and take one to each bank where you favor the bank by borrowing money. And, by the way, don't wait until March 10th to run over to your banker to have his clerk figure up your tax return. The banker does not need the exercise, and you need the knowledge of your own affairs.

I don't want to show you up, but let me ask honor bright, not in answer to me, but within your own minds, how many of you have taken that form and copied your own financial condition on to it and taken the original copy to your banker with whom you do your banking? I want you to realize if you expect us who are, as your genial president intimated, hard boiled and hard nosed, to be less so, let us know more about you. If we knew more about you individually and that you knew about your costs, it would not be so hard for you to come in and get us to do business with you. This, of course, applies to the man who has an office force and who has an expert who can figure up your return, but if you, yourself, would wade through the process of gathering the knowledge of your own business involved in making an income tax report and corporation tax report to Uncle Sam, you would get a new slant on your own business which would be very wholesome for you.

The Question of Interest and Depreciation.—In fifteen years of financing more contractors than any other banker in my town, I have found but two or three who figured interest on equipment and money used in the business. I am getting down to the question of costs. Of course we are different up there at Gary from what you are. I suppose most of you figure on interest on equipment and money used in the business. Very few have figured proper depreciation, and as for replacement, when you mention it, they look at you pityingly as much as to say, "Well, you are a banker, all right, but as a contractor you'd never land anything."

Now getting back to this proposition of landing contracts, I am going to show you whether or not I know my stuff. Have you ever observed that the fellows who take contracts from now on for the next ninety days are as a rule the fellows who work all year for practically nothing? Fellows who bid on contracts from now on have lots of time to sharpen their pencils. They figure down and they "kid" themselves a lot on what labor will cost and how they will be able to dove-tail things together and buy equipment. They will use their low figures on a yardage basis, as a basis for figuring costs instead of having accumulated a mass of experience and data over a period of years. Instead of using these bases of costs they will be cutting and grabbing off contracts just as hard as they can. I heard them down in the lobby just now saying how close they got on this contract. The chances are that someone missed it by $160 and I will warrant you that some have figured that contract on a basis in the months of January, February and March that he would not do in May, June and July. I am not asking you to answer me; I know what you are doing because I have watched this stuff for years.

Why did so many bus lines quit business a few years ago when the Public Service Commission very properly made them put up reserves for depreciation, replacement, etc? How many buses went out of operation after they were told they must put up reserves? Did you notice how rapidly those bus lines went out of business? Surely they saw the handwriting on the wall as to how little they knew about the cost of their business and as to what they were running into, and if it had not been for the Public Service Commission, even though you and I may have some private reservations on the Commission, we would have had one financial mess after another up and down the state with these bus lines. There would have been literally hundreds of damage suits that could not have been settled because the financial reserves would never have been there to have faced the issue when it finally came.

The Contractor's Profit.—I will not finance a contract or contractor who does not consistently figure a 20 per cent profit above all costs. If you'll look at the names that are on our bank books you will find they have consistently made money. I think I can tell you without violating any confidences, that year in and year out the bunch of contractors we do business with have shown consistent advances and are showing pretty generally cash balances; that they are showing equipment that is paid for and are not borrowing money to make a down payment on equipment; that they can get their own certified checks and that we have (I think I speak by the cards when I say) we have the largest bunch of contractors of any bank in that city. Some of them are not sure whether one of my eyes is glass and that possibly it has more human sympathy in it than the other one. But you will realize that that attitude means a more wholesome situation within your business. You have a right to expect co-operation and understanding and support from the banker, provided, however, you have taken the precaution to provide sufficient accurate information so he will understand what you are driving at.

What the Bank Statement Discloses.—The worst weakness among all contractors is that of failing to understand that the part of the bank statement that discloses your ratio of net quick assets, including of course

working capital, is the key to your success or otherwise in managing your business, and to whether or not you are a desirable bank customer.

I can start an argument on bank balances with a contractor quicker than anyone else—he thinks that is a banker's hobby, that the banker drags that stuff in because the banker wants him to keep more money in the bank. You will not believe that that is not the view at all, because you will find we are not so particular about how much you keep in the bank.

We are particular about the ratio of cash in your statement and the particular bracket that has to do with your net quick assets, because experience has long since demonstrated, not only in contracting, but in banking, manufacturing, and mercantile business, in any line of business, that there are some fundamental rules with respect to these ratings which, when you violate them, mean trouble, mean that you are borrowing to meet the payroll, borrowing to make down payment on equipment, etc.

Now if you don't think that rings true why you just put in any question that you think of, because I want to be corrected. I don't want to give out any wrong information. I want to know if I am far wrong in making these observations. Perhaps it should also be said, if that situation obtained generally among contractors, you would not have nearly so much trouble in landing contracts. If he has sound ratio of quick assets to fixed assets both you and I will admit he must be a pretty fair contractor, or at least a very good business man, and he will be the first to have all the costs taken into consideration and it won't be that contractor that you will fear.

Importance of Sound Rates of Working Capital.—Did you ever see the stock of a going concern that had a high market value whose management did not at all times strictly maintain a sound ratio of working capital? Did you ever hear of U. S. Steel or General Motors or a public utility borrowing to meet a pay roll or to make a down payment on equipment? If they cannot do it advantageously, are any of you such wizards that you can do it without being held up, losing discounts, being worried and losing money?

Some contractors may be bound up with some loan sharks. How did they get in the hands of the loan shark? If they had money to get over these places they would not be paying these high percentages for temporary use of money. There are fellows in the State of Indiana loaning money to you contractors at a high rate of interest. But you see at once the soundness of the position I take, and not for the banker's benefit, although that will result in cash in bank.

There is another observation that should be made about cash in bank or sound ratios, and that is that the bank's ability to loan money is determined by the deposits. I will tell you frankly that the customers' lines of credit are fixed partly by the statement, but considerably by the cash in bank, because it is out of the cash in bank, or deposits, that we loan money and if you don't keep your proportion of money in the bank, by that much you are limiting our ability to lend and we are not going to put your needs on the back of the other fellow.

Where fellows are handling a little larger volume of business than usual and where they are moving along in good shape, at times they are justified in getting more money than would be normal, but we make an arrangement frankly where they pay for that money in excess of the going market rate. It used to be fairly stiff; we used to charge one per cent every ninety days for renewal over and above the normal line of credit plus the regular interest rate. We did that not because we wanted that earning in the bank, we did not so much want that, but because we wanted to impress every ninety days on that man that he was getting something he should not have, and the best way to bring it home was to make him pay for it. Of course there is no better way to teach a man a lesson than to make him pay for it in dollars and cents. It seems an outrage, but I know of no way it can be better brought home to the contractor, the iniquity of lending to him on other men's balances.

False Crutches.—One or two other points and I am through. Some false crutches ought not to be overlooked. Don't rush public work by petitions and agitation! Rather get prominent, capable men in the political unit to program improvements for five or ten years, faster when things are slack and slower in boom and high cost times. Then there will be no tax or budget fights and no rushing in by outsiders to mess up your program. You can immediately see the advantage of such a program.

Allocation of contracts may seem sweet but it has a lot of dynamite in it that few bankers will risk knowingly and it certainly invites competition.

Let's not put much faith in legislative nursing bottles. Out of eight years as a state senator I say let it alone, except to watch against the obviously impractical and unduly restrictive.

Dont try to protect bankers by more bond exactions. A local banker thought there should be some way to protect banks by writing into that contract or into the surety blanks something to protect the banker like the material man or laborer. Now aren't all the assets of a contractor pledged before the banker can be called upon? Obviously. The banker does not have the protection of the bonding company; the banker is not entitled to that protection, and if you afforded that protection it would only make more fly-by-night contractors. If you would write into the contract with the banker and make it so the money was protected just like the laws protect now the material men and the laborer by the surety bond, you would be opening the door to double the number of contractors within six months after that law went into effect. The idea is as fallacious as guaranty of bank deposits and for stronger reasons.

So, as I stated, from the standpoint of sound banking and from the standpoint of sound contracting, you should not furnish additional protection for the banker.

The banker must use the same gumption in lending to the contractor that he does in lending to the merchant or manufacturer.

Whenever you can, buy into a bank. You will be a better contractor for having spent a year on the board of some bank, let alone the sobering influence of a chance to join bankers' row at Michigan City or Atlanta. I understand there are many more bankers in both places than contractors, and in view of the public interest at stake, no doubt the law should work out that way. That is a pretty sound system after all that makes it more risky to do business on the public's money. The law says frankly that all you have to have is ten cents against the public's ninety cents in the banking business. If you want to know how it works out, buy into a bank and you will get a slant on some points I am trying to make.

The Lowest Bidder.—Finally, and here I would put my greatest emphasis, no public body can best serve its tax public by letting contracts always to the lowest bidder. It is just as bad administration to let a contract to a man who has no equipment or who does not know his costs, and more expensive to the public in the long run, than to ignore low bids by letting to the "best" bid. The law says, and properly, to the lowest and best bidder; and the law is sound.

Our official eyes, however, stop too easily at the word "lowest." The two qualifications are essential and equally essential for sound public policy. A little more "intestinal investiture" in awarding contracts would be as wholesome as in other public affairs.

Missouri Highway Specifications to Include Arbitration Clause.—The State Highway Commission of Missouri has been considering the matter of providing for arbitration of misunderstandings and disputes arising between constructors and the State Highway Commission and have decided to include an arbitration clause in their new specifications. The commission is studying the Pennsylvania Commercial Arbitration Act and it is probable that the new arbitration clause will be modeled along the lines of the Pennsylvania statute.

Co-operation Between Engineer and Contractor

A Contractor's Opinions and Observations

By TYREE L. BELL
McElwrath Construction Co., Corsicana, Tex.

ANYONE who has ever been around a concrete paving job, knows all about Blue Mondays. Some one will tell you that they are caused by the sand, that due to the change in weather over the week end the amount of moisture in the sand has changed, and that all of the grief which we have all experienced, is brought about by the lack of a workable mixture. The contractor on the other hand, thinks that the engineer has been off on a week end party, and that he is just hard to get along with. The engineer, on Blue Mondays, usually discovers that the contractor's outfit is obsolete, that his organization is hopeless, and that he is doing everything in the world possible to try his, the engineer's patience. All of which may be true. The main thing, however, is that the engineer and the contractor are not together. What applies on Blue Monday applies also in a varying degree to all road work throughout its entire progress.

Engineer and Contractor Essentially Co-workers.—The largest of all the contractor's problems is the engineer, and conversely, the largest problem of the engineer is the contractor. Yet they are essential co-workers, almost partners, and only when they work in harmony and mutual help, can a desired end be obtained at the least expense of time and money. If either adopts a spirit of discord, or seeks to hamper the other, he is untrue to the best ethics of his profession, and disloyal to the interest of the public. And with the best intents, no doubt, but from a wrong mental attitude, the engineer is often responsible when friction exists. It is absolutely essential that in the work to be done there be a mutual interest, a mutual responsibility, and a complete understanding of the intent and purposes of what the other is about. Lack of co-operation on the part of either, or both, results in poor work. Lack of co-operation results in hurt feelings for the engineer and lack of regard for the contractor. Lack of co-operation means for the contractor, both of the above, and dollars out of his pocket. Lack of co-operation between the engineer and the contractor means to the public, not only a poor road after its completion, but an annoying and expensive delay in getting the use of the road while the engineer and the contractor wrangle among themselves.

Conditions in Contracting Business.—In this paper is presented the view point of a contractor, actuated by the desire that the engineer may in some degree be brought more clearly to understand the problems of the contractor, and tempered by the recollections of a several years personal experience as an engineer dealing with contractors. To understand the problems of the contractor, the engineer must have an insight into the conditions which today affect the business of contracting. Never before has the contractor had to face such obstacles as are in front of him today. To say conditions are chaotic only puts it mildly. You only have to examine the records of lettings in Texas in 1927 to get the results of the conditions which I shall mention. The inexperienced and under-financed contractor is having his day in Texas, as he is throughout all of the country. Unsound bond practices permit any contractor who happens to be low bidder on a job of any magnitude to make bond. Unsound lien laws guarantee all material and equipment dealers against loss, regardless of the financial condition of the contractor. False credit allows almost anyone who has nerve enough to sign his name to a note, to finance the largest of the contracts which are being let. These are conditions of the times. A declining market on all materials, cheap and eager labor, and wonderfully improved machinery, have made it possible for almost any contractor, regardless of his bid, to get by. I do not mean that they are making money, but they are, through low prices which they are bidding, practically destroying road contracting as a legitimate business for the properly financed contractor. Recently I was shown some startling data concerning the mortality of those contractors who have pioneered the business in this state. It showed that among all those who were laying concrete paving four years ago in Texas there were only about five of them who were even bidding in 1927 and 1928. It showed that an amount in excess of 80 per cent of the concrete road work which was let by the Texas Highway Department during the last year, was let to contractors who never before had laid concrete paving in Texas.

Contracting a Business Proposition.—The contractor goes into it with the idea of making money. If he fails to do so, he either turns his work over to the bonding company or withdraws from the contracting game and puts his finances and talent to work in a more remunerative field. Prices we all know are too low; so low, that there is slight chance of them going any lower. But even at the extreme low prices at which the work is now contracted, there still remains for the husting ingenious contractor, while waiting for the better days to come, an opportunity to make a slight return on his investment and time, if on the contract in which he enters, he is allowed to expedite the fulfillment of his undertaking, unhampered by interference with his operations, and encouraged by the active co-operation of the engineer who is in charge of the work.

It is not the purpose of this paper to outline any highly theoretical analysis of the inter-relations between the contractor and the engineer, but to explain, and straight from the shoulder express, certain basic facts, opinions and observations which I have gathered through an experience of several seasons in building roads. In various localities, during those years, I have been told daily by engineers what to do, and when and how to do it, but the opportunity presented me to speak to engineers on co-operation is a novelty, and now I am going to take the fullest advantage of the privilege to tell you engineers what you should do.

When the Relationship Begins.—The relationship between the engineer and the contractor begins long before the contract is signed. It comes when the plans and specifications are started. Although who the contractor is to be, is not known, his problem of carrying the work to successful completion can be simplified, if when the engineer prepares his plans and specifications, the engineer gives the proper thought to how those plans and specifications will affect the operations of the contractor with whom he will be called upon to deal. You engineers, in your plans and specifications, be sure that you have removed every possibility of uncertainty and ambiguity. Make up your mind definitely as to what you want and write definite specifications. Study your local conditions and adapt your work to them. Do not make your specifications a bunch of "don'ts," a lot of traffic laws, as it were, with the intention of employing an inspector as a

traffic officer to enforce the laws. Visualize the work to be done. Be creative, constructive. Take out of your specifications all non-essentials. Be brief and explicit, and in that way your specifications can be understood and followed. Frequently I have seen engineers draw specifications for superpavement. The results have always been the same. The award of contract has been to some one irresponsible, who either did not understand the exacting requirements intended or who thought that through local pressure, or by suffrance of the engineer, he could get by without doing those things which the specifications said he must do. Either such an irresponsible award will be made, or the public will pay a price in excess of that commensurate with the result. Don't practice self delusion and specify impossible perfection. Remember you pay for what you order. Determining whether the superresults you seek are worth what it costs you. Above all, specify results. Reduce to a minimum the specifying of methods. Familiarize yourself with the consistent findings of all of the courts, and learn that when you dictate and control the methods, you alone are responsible for the results, not the contractor.

The Position of the Engineer.—After the award of a contract, the relationship between the engineer and the contractor becomes something definite. The engineer owes a solemn duty and responsibility to the contractor. It is said, for instance, in the specifications of the Texas State Highway Department that the engineer is a referee, that it is mutually agreed by both parties to the contract that the engineer shall act as referee in questions arising under the terms of the contract between the parties thereto, and the decision of the engineer in such cases shall be final and binding upon both alike. Mind you it did not say that the engineer was one of the contracting parties, but that he was the referee between the contracting parties. He owes just as solemn an obligation to the contractor to see that he is treated fairly, and that he gets all to which he is justly entitled, as he does to the public, which employs him, to see that they get the character and amount of work for which they contracted. The position of the engineer is comparable to that of the architects, and you will find in the Code of Ethics of the American Institute of Architects the responsibility of the architect placed as follows: "As the architect is the interpreter of the conditions of the contract and the judge of its performance, he shall decide neither with the owner nor with the contractor but shall use his powers under the contract to enforce the faithful performance of both."

The Item of Extra Work.—In carrying on any construction project changes will have to be made as the work progresses. There are contingencies to be met. The contractor expects to meet those contingencies, but he expects to be paid for doing so. There will be extra work to be done. Every contract provides that extra work is to be paid for. The contractor is willing to do all such extra work, and he only asks that he be paid for the expenses involved and a fair profit on the extra work, just the same as if it were in the original contract. Emphasis should be laid on the fact that the contractual relation is a mutual relation and that any change in the details of the contract as originally drawn must be agreed to by both parties. Any change, no matter how minor that change may be, may introduce conditions not contemplated when the contract was drawn, and demands financial recognition, consideration and adjustment. It is merely a matter of business. The contractor has agreed to do one thing; he is asked to do something else. The original agreement was a matter of business between both parties. Therefore, the change is no less a matter of business adjustment between the two.

Without exception all such change orders should be given in writing. No modification of a written contract is of much standing unless it is reduced to writing. Leave nothing to memory. The best memories fail often, so often, that even if it were legal to do work on the basis of memory, it would still be inexpedient to do so. Memory and conversation obtain scant credit when a written contract is under review.

Let the contractor run his outfit unhampered by volunteered theories, ideas, or whims, no matter how excellent the engineer may think they are.

One of the Causes of Misunderstandings.—A cause for frequent misunderstanding between the engineer and the contractor is the desire of the engineer to have the work done in some particular way which his specifications do not require, and which is not the contractor's way. The contractor ordinarily will comply with the whims of an engineer to do the work in a particular way in order to keep him in good humor. However, such practice is unbusiness-like and costs the contractor money. When the contractor bid on the work he did not know what the whims of the engineer might be. He bid on the work in compliance with the plans and specifications and the methods practiced in that locality, and any change from such methods required of the contractor will likely cause him additional costs, and he should not be forced to bear them without additional compensation. You will note that I have spoken of customary methods in that locality. The contractor is entitled to follow such methods as have been permitted to others in that locality just so long as he is not specifically advised in a notice to contractors that such methods will not be permitted. The courts have all so held. In other words, the contractor cannot lawfully be required to abandon a customary method because the engineer in charge of the work believes another method better, even though in the engineer's opinion the phraseology of the specifications would make the proposed method an appropriate method. He bid with the customary purpose in mind and this established his responsibility under the contract. The preference of the engineer is no part of that very important document, the contract.

What Plant Delays Cost.—It is a day of plant and organization. The building of concrete roads in a manufacturing enterprise, requiring unfaltering machinery, skilled operators and co-ordination between the supply and demand of materials. You can consider the whole as a machine, a highly sensitive machine, one accomplishing a surprisingly large output, yet one likely to be thrown completely out of balance by the slightest discord. The contractor knows the machine and he has his own theory and methods of getting the maximum efficiency out of it. Any interference is costly to him. It is estimated that it costs the contractor about $400 a day to run a modern concrete paving plant, outside of all considerations of materials. That means $40 an hour for a 10-hour day. Therefore, all delays of the plant cost the contractor at the rate of $40 an hour and proportionately prolong the time necessary to complete the project.

The cost to the traveling public is to be considered, and the cost to them for each day's delay in getting the use of the road is tremendous. The engineer should encourage to every reasonable degree the speeding up of the output of the contractor.

Experienced Inspectors Needed.—The co-operation that the contractor needs and expects applies not only to the engineer, but to the engineer's assistants, and particularly to the various inspectors placed in charge of the work. The specifications specifically require that the contractor, for certain operations, employ only experienced workmen. Is it no less important that the engineer should employ only experienced inspectors? Is it consistent for the contractor, at considerable expense, to train his men and pay them high wages in order to get competent and experienced men, then be forced to place such men under the direct control of inspectors who have little and frequently no experience on work such as that on which they are put in complete charge? We can all remember the day not so far distant, when the frequent complaint of the contractor was that the engineer was sending out on to his work as inspectors young chaps just out of engineering school who had no practical experience. Isn't it much worse today to find that instead of sending young technical graduates out, they are placing in complete charge of the details of the contractor's operations, either

boys who are not through with high school, or local political pets.

Above all the punishments that may be administered to a contractor operating a modern paving plant, is to be compelled to suffer the constant delays brought about frequently by the bickering and nagging of a green and inexperienced boy who orders the mixer shut down every time he sees some little detail not in exact accord with the misconception he has in mind. Of all the co-operative measures that the engineer could institute, nothing would effect as far reaching results as the proper training of his inspectors towards the results which are desired, the responsibility of the inspector and the limits of his responsibility. No matter how expert the contractor's organization, no matter how efficient his equipment, satisfactory and remunerative results cannot be obtained from it, if there exists the discord and handicap so often evidenced in the person of the inspector on the job.

How the Daily Run Was Increased.—Within recent years I saw a concrete paving organization try month after month to get going without success. Superintendents, foremen, and operators were hired and fired in an effort to get production. But in spite of it all, the average daily run remained around 300 ft. Finally the thought suggested itself to the engineer that part of the trouble might be in his inspector and the inspector was removed. Within a week the daily output of the plant was increased to approximately 800 ft. a day and never thereafter decreased during the life of the job. It is not claimed that the inspector on this work deliberately deprived the contractor of 500 ft. of paving a day, but the contractor knew that by constant nagging, stop orders, discord and general interference with his operation, the inspector was directly to blame for the lack of production. Such an example is unusual, but it shows to what extreme the interference of an inspector may be carried.

The laying of paving is no exact science, and the more experienced an engineer becomes, the more tolerant he is in his requirements. Improved as modern road methods are, it is not a day of perfection. Such a precedent for tolerance is exhibited by the specifications of practically every state in that they make an allowance of a ¼ in. in the subgrade, or make a price adjustment for an increase or decrease in thickness. How frequently we see in Texas, jobs constantly shut down by the inspector for the reason that the subgrade does not exactly conform to a templet.

Encourage speed in your contractor's operation, assist him in obtaining speed, but do not go speed crazy. The contractor has a definite accomplishment in view. He has taken the contract with a certain definite objective, and that objective may not be, to surpass the daily runs of some other contractor in a neighboring county, where the conditions or at least objective of that contractor, may be entirely different. If the contractor seems reasonably sure of completing his work with the time limit of his contract, do not attempt to take the control of his operation out of his hands in order to secure the advertising of breaking some records.

Staking Out the Work.—The matter of staking out work is one in which the engineer may be of great assistance to the contractor by furnishing him with such stakes as are adapted to the way the contractor wants to handle his work. It should be seen to that stakes are always maintained well in advance of any one of the contractor's operations. The instrument man should be supervised to the extent that it is certain that adequate and proper staking is done. Frequent abuses occur, where through the laziness or lack of interest of field assistants, the contractor is hampered in his subgrading and form setting by the lack of proper stakes. As an example in point, I once well within my recollection, was forced to build a federal aid project in another state where the resident engineer in charge, being his own instrument man, through laziness refused to give me any stakes whatever. I was given a sheet merely listing the grade of the slab over the blue tops which had been given for the rough grading, and which by-the-way, had been done by another contractor.

Under the present practices in Texas, the grading is usually done under a separate contract. The contractor building the slab has to deal with a dump resultant from the action of the elements and shrinkage. Dirt and its shrinkage never behave on the basis of what was intended. Therefore, before a grade is established for pavement, the grade of the existing road bed should be carefully profiled and the new grade adapted just as closely as good practice permits. Commonly, as a matter of design, the selection of a grade line is governed more by personal preferences than by any established rules; so its minor modification in the field offers no great difficulty and causes no reduction in the value of the finished pavement. Once in a while the contractor gets to do work under an engineer who has had considerable railroad experience, and he thereupon learns the advantage of a running grade. In such cases the grade stakes for the pavement serve merely as a datum, and the contractor is allowed to vary the elevation of the subgrade to any reasonable degree, just so long as he does not break the grade to such an extent that it is noticeable to the eye. A break in grade on a paved road of one tenth of a foot per station is not discernible to the eye, nor to the traveling public, and yet may allow the contractor to build his subgrade with a considerable saving in excavation or fill.

Proportioning the Mix.—In proportioning the mix, the engineer under all specifications is given a wide latitude through which he may assist the contractor in both the economy of materials and the securing of workability in the concrete. If the contractor knows his business, he can, as all of those who are familiar with modern concrete practice know, through the selection of materials and the proportioning of them, secure a much more economical mix than is afforded through the usual haphazard proportioning. The engineer should, through his knowledge of economical proportioning, lend every assistance to the contractor in securing the most economical mix.

Workability is one aim that is ever present with the contractor. The more workable the mix, the more cheaply he can place the concrete, and the better he can finish it. What is workability? A recent meeting of the American Concrete Institute gave practically its entire program to an endeavor to secure a definition and a measurement of workability. They wound up by admitting that there was now no way of measuring it. Yet take any experienced concrete road finisher, be he negro or Mexican, and he knows what workability is, even though he doesn't try to measure it. Without any rules or theories, if you will let the mixer foreman and finisher get the mix that suits them, you will find that they will achieve "workability."

The Experienced Paver Operator.—Consistency is an element of workability. Even with the most modern improvements of inundation and water measuring devices, consistent consistency cannot be obtained without the skill of the experienced paver operator. You will find that such an operator can and will insure proper consistency, if let alone. Therefore, do not hamper him by permitting an inspector to be climbing up and down the mixer throughout an entire day regulating the quantity of mixing water. Quite frequently I have seen aroused considerable interest of engineers who have visited paving jobs where a certain experienced mixer operator was at work. Without any regard to the water gauge, he can, batch after batch, day after day, turn out a mix that to every slump measurement is of the same exact consistency. How does he do it? It is because for several years he has stood beside the same motor and tuned his ear to its varying hum as the water was added and the mixing carried on. Knowing the consistency that the engineer wants, he gives it to him. He has learned that when a given consistency has been obtained in the drum, the motor immediately announces it by a certain recognized tune to its hum. Modern inundation and water control can secure the same results

that Bill has gotten for years, but they cannot surpass it.

Finishing a Concrete Road.—The finishing of a concrete road is a trade or a craft in itself. Contractors are required to employ skilled finishers. If they were not so required they would do so anyway, because experienced and skilled hands and eyes are absolutely essential in order to obtain required results. Earlier in this paper I asked that you specify results instead of methods. Again I bring up this subject, and ask that you demand results and do not try to dictate methods. All modern specifications have a definite requirement as to the measurement of the surface finish that the contractor must secure. The compliance of the contractor can be measured at any time and as often as desired by the simple application of a rule and straight edge. Why demand of him that he use a certain kind of screed; that he operate a certain kind of float in a certain way; that he belt the surface at some certain time with some certain type width belt? Isn't your essential aim, results? Why not then let the contractor and his finisher secure the specified results through their own methods and with their own tools, with which they are much more skilled than are you? The longitudinal float, the belt, and the screed have no virtues in themselves. They are merely tools. You should not be interested in tools, but in the riding qualities of your pavement. The contractor should be required to give you a specified surface before his work is accepted, but you should not demand that he secure it through some pet method with which you may be partial. I have seen jobs frequently where an inspector with only a few months experience would stand over a finisher who has spent his life in learning his trade, dictating to the finisher when and how to edge a joint, or float a surface. Again I say, check him with a straight edge, but let him alone.

The Contractor's Crew.—A contractor's crew is his stock in trade. Let him hire it, organize it, and control it in his own way. He knows his men and they know him, and if he has an experienced organization you will find in the end that they have accomplished the results you want. But on the other hand, if you want to cause some real trouble, disorganize the contractor's force, and, in general, work havoc with the control of his organization, ask of him or demand of him, that he hire some certain finisher, form-setter, or foreman that you have known on some other contractor's work. The contractor will usually comply, but it will not be a week before the contractor will be given to understand by the favored employee that he is working for the engineer, not the contractor, even though the contractor is still expected to sign his check. I believe that any engineer would do well, if as a matter of policy, he would never suggest any employee to any contractor unless such contractor had asked him where he could find some particular clas of man.

What the contractor wants the engineer to do is to take responsibility. He wants him to be definite in his requirements. He may be just as hard and exacting as he wants to be, but if he will be definite in his requirements, and fair in his settlements the contractor will find no fault with him. For an engineer to deprive the contractor of any rights which may be his, require him to use more materials or to do extra work which the contractor is not obligated by his contract to do, in order to make an impression on his superior or employer, is just as wrong, unfair, and unethical as for the contractor to fudge on the use of materials in order to make an impression on his financial statement.

The day of paving in Texas has just begun. There is a vast amount of prospective work ahead of us. We all know of the State System of roads to be completed. The counties themselves are launching big programs for lateral hard surfaced roads. There is going to be sufficient work to interest and keep busy all properly qualified engineers and contractors of this State. To reap the greatest benefit from the program ahead of us we should work together to our mutual advantage, maintaining sympathetic understanding and appreciation of the problems and interests of the other. Mutual trust must be established. The day of the alleged old time contractor is gone. The contractor today must be an energetic business man getting his work through low bidding and completing it in exact conformity with plans and specifications. If the engineer will just take for granted that the contractor is honest and wants to do the right thing, he will encourage and help the right kind of contractor to stay in the business. The State needs good contractors. It will be well for engineers to analyze a statement which I recently read. It was, that it is possible for a good contractor to secure good work even when hampered by a poor engineer, but that it is absolutely impossible for an engineer, no matter how good he may be, to secure good work when he has to deal with a poor contractor.

Acknowledgment.—The foregoing is a paper presented at the Fourth (1928) annual short course in highway engineering at College Station, Texas.

New Batcher Type Bin

A new type of all steel hopper bottom bin, known as the Type "B" Batcher Bin has recently been put into production at the new plant of the James B. Seaverns Company at Batavia, Ill.

The type "B" bin is designed to come within the railroad and highway shipping limits; the body frame being 10 ft. wide by 14 ft. long with removable posts or legs which are quickly set into place on arrival at the job. The batcher gates which are of the Duplex type are attached directly under the hopper and above the lower chord of the main side trusses so it is not necessary to remove them for shipment. Only the four legs and two batch hoppers are detached when folded for shipment cutting down the assembling time to about an hour with the use of crane, the manufacturers claim.

The top of bin is 10 ft. wide by 19 ft. long inside and so arranged that various capacities are obtained simply by adding sectional side boards of pressed steel plates 12 in. in height. Each sectional unit containing just 7 cubic yards thus any size bin can be shipped from stock for capacities 23 to 51 cubic yards in 7 yard variations for both sand and stone compartments.

The batch measuring and weighing hoppers are hung from a duplex strike off gate unit operated by one hand chain for both gates. These gates are of ¼ in. steel plate and special 10 in. steel channel construction. They are mounted on frictionless roller races and require very little effort for their operation. The drop bottom doors which are of ¼ in. steel plate are equipped with automatic latches and counterweights. When the doors are tripped, they are locked open, permitting full discharge of contents; another pull releases the weights and re-sets them for another batch. The batchers are adjustable from 8½ to 17 cubic feet for sand and from 14 to 29 for stone. They are of $\frac{3}{16}$ in. and ⅛ in. steel plate and thoroughly galvanized to prevent rusting. When so ordered, they are equipped with automatic counters to record the number of batches per day shipped.

Roads with Concrete Lines

M. Závodník, C. E., describes in No. 3 of the Zprávy veřejné služby technické (Jerusalemská 11, Prague II), a method of laying down lines of concrete slabs in ordinary thoroughfares of road-metal. On the district road at Fichtenbühl near Weiden (Neustadt, Germany) there have been laid down, in the middle of the thoroughfare, concrete slabs 50 centimeters wide(25 long and 18 thick, made of crushed material (basalt, granite) or of sand and high-burnt cement in the proportion of 1:4. The inner edges of the concrete lines are distant one meter from each other, so that heavy vehicles can move quickly over them. Experience shows that these concrete zones are suitable for sections of local roads in front of mills and factories (for example, sugar factories), in which case, however, it is advisable to give the concrete lines a width of 75 centimeters, so that the ordinary road-metal zone between them is narrowed to 50 centimeters and is not worn down.

The 12-Mile Concrete Demonstration Road In Virginia

Construction Features Described in June Public Roads

By A. C. BENKELMAN

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THE Virginia demonstration road was constructed to determine the influence of a number of materials and methods of construction upon the behavior and life of concrete pavements. It consists of 60 sections varying in length from 100 ft. to 1 mile, and with an aggregate length of 12 miles. The work has been done as a Federal-aid project by the Virginia State Highway Commision under the direction of Henry G. Shirley, chairman, and C. S. Mullen, chief engineer, and is known as project 336, sections C, D, and E.

The location is on the main route from Washington, D. C., to the Valley of Virginia between Fairfax and Warrenton and crosses the famous Bull Run battlefield. Previous reports have been made concerning the construction of this project.[1]

Object of the Investigation.—As indicated by the number of sections constructed, the experiment embraces a large number of variables. The slab cross section was varied in several instances, but study of this factor was not a primary object, since the efficiency of the standard Virginia cross section (8 in. thick at the edge, 6 in. thick at the center, and 18 ft. wide) was not in question in this investigation. It was desired primarily to learn the relative benefits or adverse effects of different aggregates, different admixtures, different types and weights of reinforcement, different methods of finishing, various methods of curing, and different methods now used for the control of transverse and longitudinal cracking.

In order to properly evaluate these variables, there was included also a study of the influence of such factors as subgrade conditions, climatic conditions during construction, the consistency and water content of the concrete mixes, and the strength of the concrete as indicated by tests on cylinders, cores, and beams.

General Features of Project.—The new road in general follows the horizontal alignment of the old Warrenton Turnpike. The vertical alignment was modified to such an extent that in only a very few instances does the new surface rest directly upon the old roadbed. The original road was in existence at the time of the Civil War and perhaps many years prior to that period. It has been improved from time to time and has served as a line of travel to the Valley of Virginia from the east. The earlier improvements involved the construction of a stone base and sand-clay or broken shale surface. The character and thickness of the base depended apparently upon the nature of the subgrade encountered. Large boulders were used for the subbase in the clay soils and poorly drained areas and shale fragments were used in other locations.

The new road was built with state equipment and convict labor. A superintendent, acting under the direction of the resident and district engineers of the state highway commission, was in charge of the various construction activities. A field camp was established in the fall of 1925 at the quarry on project 336 C (station 485) and served as the operating base for the construction of projects 336 C and D. The camp was moved during the summer of 1927 to a new quarry site on project 336 E (station 900) and construction of this project carried on from this point.

Materials were proportioned from stock piles at the respective operating bases and were transported to the mixer in trucks. The concrete was mixed with a 4-bag 21-E Koehring paver equiped with a batch meter and water-control mechanism. The water was pumped to the paver from nearby streams and was generally clear, free from impurities, and gave a satisfactory strength ratio in all tests.

The maximum grade of the new pavement is 7 per cent. There are only a few changes in alignment in the entire road and these are so slight that the pavement is not superelevated.

The Virginia specifications require a 6-ft. shoulder on fills with an embankment slope of 1½ to 1 and a 7-ft. shoulder in cuts with a slope of 1 to 1. the shoulders are composed of the natural soil with a slope of ½ in. to the foot.

Many Variable Features Included in Design.—The major differences in the details of the section are as follows:

1. Three cross sections, 8-6-8, 9-7-9, and 7 in. uniform.
2. Three methods of finishing—hand, Vibrolithic, and machine (Ord and Lakewood).
3. Five admixtures—hydrated lime (5 and 8 per cent), Celite (3 per cent), diatomaceous earth (3 and 4 per cent), calcium chloride (2 per cent), and Cal (5 per cent).
4. Five methods of curing—wet earth, calcium chloride, and sodium silicate (surface), calcium chloride and Cal (in the mix).
5. Materials—three cements (two Portland and lumnite), two sands (different character and grading), two crushed stones (same character and grading, different sources), and two gravels (same character, different grading).
6. Five mixes—1:2:4, 1:2½:3½, 1:3:3½, and 1:1½:3, all without correction for bulking, and a 1:2:4 mix with correction for bulking.
7. Three types of reinforcement—welded fabric (single and double layer) expanded metal (single layer) and bar mat (single and double layer).
8. Joints—transverse (construction and expansion) and longitudinal.
9. Planes of weakness—transverse (with different spacing) and longitudinal with and without dowels.
10. The subgrade consisted of 10 different soil types, some of which were treated with 1 in. and 2 in. layers of stone screenings and one and two layers of tar paper and one layer of Mosinee paper.

Cross Section.—In the thickened edge design the subgrade was parabolic from the edge to the center. The pavement surface of the hand and machine finished sections was curved with a crown of 2¼ and 2 in. respectively.

Finishing.—Tools for hand finishing consisted of a steel strike-off template 10 in. in width and weighing 600 lb., a transverse wooden float 24 in. in width, and a belting machine. Six men, three at each end, manned the strike-off template. Three men spread the material and three tamped ahead of the template. In addition, two men spaded the material along the side forms. Generally three men were engaged in floating, belting, and finishing; two were employed in wetting and placing burlap.

The Vibrolithic concrete was mixed, deposited, and screeded as in the case of hand finishing. After screeding, coarse aggregate was applied uniformly to the surface at a rate of 50

[1] Hogentogler, C. A. Virginia Building Demonstration Road. Public Roads, Vol. 7, No. 6, Aug., 1926.

Albright, J. C. Virginia Demonstration Road. Proceedings of Sixth Annual Meeting of the Highway Research Board, Dec. 2, 1926.

lb. of stone per square yard and was vibrated into the fresh concrete by means of the vibrolithic platforms and motor carriages. Following this process, the pavement was finished in the usual manner with transverse float and belting machine.

Of the finishing machines, the Lakewood machines had the combination tamping and screeding features, while the Ord had only the screeding feature. Both machines were new and represented the latest model of the respective companies. It was possible to reduce the labor required by six men with the use of either machine, as compared to hand finishing.

Admixtures.—The hydrated lime, celite, and diatomaceous earth were used to determine their effect upon the workability and quality of the concrete. They were added dry to each batch of material at the proportioning plant, the percentages of each being based upon the weight of the cement. The Cal and calcium chloride were used as a substitute for surface curing. The former was added dry to the mix and the latter was first dissolved in water and was then added as the materials were being emptied into the drum of the mixer.

Curing.—Where concrete containing Cal and Calcium chloride was laid the pavement surface was protected with wet burlap for 24 hours and then exposed to the weather without further attention. In the wet-earth method the earth covering was applied in a 2-in. layer within 24 hours after laying and was moistened twice a day for two weeks. The calcium chloride was applied to the surface within 24 hours in the dry state at a rate of 2 lbs. per square yard. The sodium silicate was mixed with water in the proportions 1 part water to 3 parts sodium silicate and applied to the surface in such quantities as not to run or collect in pools. As in the case of the Cal and calcium chloride used as admixtures, no further attention or treatment was given the pavement surface. For all the various methods of curing the surface was covered with wet burlap during the initial 24-hour period.

Materials.—All materials were such as would be selected to obtain a first-class concrete. The two brands of cement both conformed to the standard A. S. T. M. requirements and gave practically the same results in laboratory tests.

One of the two sands used was a washed river sand consisting largely of subangular and rounded grains of quartz, chert, sandstone, and gneiss, and had a silt content of 2.5 per cent. The other was washed bank sand consisting largely of angular quartz particles with some grains of feldspar, and contained 0.5 per cent of silt.

The crushed stone was a local diabase rock, of exceptional quality, having a low absorption value, a high degree of toughness, and a low percentage of wear. The crusher-run material between the 2½-in. and ¼-in. round screens was used.

The gravel was a washed bank material consisting mainly of rounded fragments of quartz and chert. The maximum and minimum sizes of the coarse gravel (No. 1) corresponded to that of the stone, while the fine gravel (No. 2) ranged from 1½-in. to ¼-in.

Correction for the bulking of the sand was not made in the 1:2:4 mix used in sections 1 to 25 and 44 to 45 in the 1:1½:3 mix (sections 43 A and 43 B), in the 1:2½:3½ mix (section 9), or in the 1:3:3½ mix (section 38). In all other cases the 1:2:4 mix was corrected for bulking and approached a field mix of 1:2½:4 proportions.

Reinforcement.—The sections in which reinforcement was used and the details of the mats together with related information are given in Table 1.

Joints.—Construction joints formed by removing a wooden header and laying the new concrete directly against the old were installed at noon and night on project 336 C and on section 45 of project 336 D. On projects 336 D and E, ½-in. expansion joints were placed every 40 ft for a distance of 500 ft. on each side of all bridges. Otherwise, ½-in. bituminous felt expansion joints were installed at noon and night on project 336 D (section 45 excepted), while a double thickness of the same material was installed in a like manner in the sections of 336 E.

Planes of Weakness.—The planes of weakness or impressed grooves were approximately 2½ in. deep by ¼-in. wide at the base and from ½-in. to 1 in. wide at the top and were installed with a special machine, the Flex-Plane. The machine bridged the pavement slab and traveled on the side forms immediately behind the hand screeds or finishing machines. It was used to install both longitudinal and transverse grooves and was adjustable so that it could be used on pavements up to 24 ft. in width.

When a longitudinal groove was being installed a spading tool which operates as the machine is propelled forward first opened a preliminary groove by displacing or pushing aside the coarse aggregate. After the machine has been moved forward a distance of 10 ft. a V-shaped metal form was forced into the depression by means of a mandrel and two compression screws on the machine. The mandrel was then raised and moved out of line. The machine was again propelled forward and another form placed. These two forms are then connected and held in horizontal alignment by an expanding bar. In the installation of a transverse groove a form is set on a mandrel and forced into the undisturbed pavement surface by means of compression screws. In some instances considerable difficulty was experienced in the installation of the transverse grooves.

As a general rule the expanding bar and V forms were removed the morning following their installation. No trouble was experienced in removing the forms when the concrete adjacent to them had been edged.

The planes of weakness were installed transversely only, longitudinally only, in combination, and in combination with a longitudinal steel center joint.

In the sections where reinforcement was used in combination with the longitudinal plane of weakness the steel mats were continuous across the slab. In a number of sections the slabs formed by longitudinal planes of weakness were connected by dowels, but in no instance were the slabs formed by transverse planes of weakness connected by dowels or reinforcement.

Two sections (27 and 28) were constructed with a tongue-and-groove doweled center joint for comparison with sections having the longitudinal plane of weakness.

Subgrade.—Ten different types of soil are represented in the natural sub-

Table I.—Details of Reinforcing Mats

Type	Sections	Planes of weakness: Transverse Spacing	Planes of weakness: Longitudinal	Joints: Construction	Joints: Expansion	Wt. per 100 sq. ft. lbs.	Shape	Strands: Diameter	Strands: Spacing	Lap in.	Depth from surface
One layer welded fabric	7	None	None	Noon and night		42	Round	6-gauge	6x6 in.	6	2½ in.
	33	40 and 100 ft.	Groove		Noon and night	42	Round	6-gauge	6x6 in.	6	2½ in.
	41	40 and 100 ft.	None		Noon and night	42	Round	6-gauge	6x6 in.	6	2½ in.
Two layers welded fabric	8	None	None	Noon and night		85	Round	6-gauge	6x6 in.	6	2¼ in. (upper layer)
	9	None	None	Noon and night		85	Round	6-gauge	6x6 in.	6	2¼ in. (upper layer)
One layer expanded metal	42	40 and 100 ft.	Groove		Noon and night	42	Square		Diamond	6	2½ in.
	40	40 and 100 ft.	None		Noon and night	42	Square		Diamond	6	2½ in.
One layer bar mat*..	30A	40 and 100 ft.	Groove		Noon and night	50	Round	2⅝-in.	21x24 2⅝in.	15	2½ in.
	30B	None	Groove		40-ft. centers	50	Round	3⅝-in.	21x24 3⅝in.	15	2½ in.
	37A, 37B	40 and 100 ft.	None		Noon and night	50	Round	3⅝-in.	21x21 in.	15	2½ in.
Two layers bar mat..	36	40 and 100 ft.	None		Noon and night	100	Round	3⅝-in.	21x21 in.	15	2¼ in. (upper layer)

*All bar mats have two marginal bars 4 in. apart. Mats (sections 30A and B) have in addition a longitudinal bar on each side of the longitudinal plane of weakness spaced 6 in. apart; other longitudinal bars are spaced at 24⅝ in.

grade. The character of these various types ranges from a friable, well-drained shale to a dense impervious clay. The heavy grading and bridge work was generally completed the same year as the paving. No artificial drains were used in the experimental sections and, excepting an occasional layer of stone screenings and both double and single layers of tar paper on certain sections, no special treatment was given the subgrade. The stone screenings were used more to expedite construction than as a subgrade treatment.

Weather.—In addition to the normal daily variation in temperature, humidity, and wind velocity, seasonal variations in weather from early spring to late fall were encountered.

Construction Operations Closely Observed.—From two to four observers from the Bureau of Public Roads were assigned to the project to obtain information on the construction and behavior of the different sections. As a general rule representatives of interested commercial organizations assisted in familiarizing the organization with special construction features of the sections or with the operation of special equipment. The observations included the following:

Subgrade.—The number of soil types, their marked difference in character, and the variety of subgrade conditions encountered suggested that special emphasis be placed upon this phase of the investigation. A general survey was made, in cooperation with the Bureau of Chemistry and Soils of the Department of Agriculture, showing the location and extent of the soil types, the thickness of the layers, and variations in character within the types. Representative samples of the different layers of the various types were selected and tested in the laboratory of the Bureau of Public Roads. Samples were also taken from the finished grade at every station immediately prior to paving and tested in the same manner.

Data collected during the progress of the preliminary and final grading and immediately prior to paving were as follows:

1. Time of preliminary and final grading with respect to the time of placing the concrete.

2. Condition of the soil with respect to its moisture content, type of hauling, and intensity and frequency of rolling during heavy grading.

3. Condition of the soil with regard to compactness, degree of smoothness or rutting prior to paving.

4. Nature and extent of underlying shale and rock and their position relative to the pavement. Information was obtained from the landowners along the right of way pertaining to the nature and location of underground springs and seepage areas.

All outstanding conditions that existed or developed in the grade during the course of construction were fully described and classified and it is expected that information concerning the influence of such conditions upon slab behavior will be obtained from these locations.

Weather.—Hourly observations of the atmospheric conditions were made throughout the period of construction. Such information as temperature, relative humidity, degree of clearness, and intensity of prevailing winds were obtained, as well as the amount of rainfall.

Materials.—Inspection was maintained at all times as to the quality and quantity of the materials being used in the concrete. Tests for gradation were made on representative samples of the coarse and fine aggregate from each day's run. In addition, four samples of sand were collected each day, on which moisture determinations were made. These latter tests were primarily for the purpose of computing the water-cement ratio of the mix and for correction for bulking of the sand induced by moisture variations. Each car of cement was sampled and tested in accordance with the specifications of the Virginia Highway Commission. During construction of project 336 E in 1927 samples of cement were obtained and tested from those batches from which the beam and cylinder specimens were made.

Admixtures and curing agents.—The effect of integral materials upon the workability and yield of the concrete was observed. Ease of handling and finishing were considered as measures of workability. Yield data were obtained from records of number of batches and thickness and length of pavement.

Steel Reinforcement.—Observations were made concerning the depth of the steel mats from the surface, the degree of lapping of the mats, and the additional labor necessary to handle and install the mats in the pavement.

Finishing Methods.—Observations on the different methods of finishing included the amount of labor, the relative compactness of the mass after the operation, and the effect upon the vertical and horizontal alignment of the forms.

Condition surveys were made 24 hours after placing when the wet burlap was removed and after the curing period, which was about one month. Future surveys are to be made each spring and fall. The surveys include observations of the developed surface and slab defects, such as checking, cracking, breakage, and faulting. The behavior of the planes of weakness and expansion joints is also observed.

Record Charts.—A graphic chart was made to correlate and show in a condensed manner the results of observations made during the construction of the road.

These records give in detail the time of depositing the concrete and the time of finishing and covering the pavement with wet burlap. They give the slump, the water-cement ratio, and the temperature of the concrete at the time of depositing. The condition of the atmosphere as regards wind, clearness, humidity, and temperature when the concrete was poured is shown. They indicate the thickness of the slab at 25-ft. intervals and contain information on the subgrade such as a description of the soil type and condition of the grade immediately prior to paving. The depth and extent of the cuts and fills at the center line of the road and the relative position of the ground line on either side are shown by a profile. They give a picture of the condition of the pavement at 24 hours after the curing periods and at subsequent periods.

Test Specimens.—Three 6 by 12 in. compression cylinders were cast from a representative batch of each day's run. The location of the batch in the pavement slab was marked, and a core was drilled from the location subsequent to the curing period. The core and cylinder were then tested in compression simultaneously.

On project 336 D and in sections 46, 47, and 48 of project 336 E, in addition to the compression cylinders, five 6 by 6 by 30 in. beams were cast each day from the same batch of material. These were cured in a manner similar to the pavement slab and were tested by bending (cantilever method) at ages of 7, 14, 21, 28, and 90 days. In sections 49, 50, 51, and 52, a special study of curing methods was made, and a total of 320 beams was cast, 80 to each section. On each section 20 beams were cast on four different days, and half of the number were cured in the same manner as the pavement slab, while the other half were exposed to the weather after the usual protection for 24 hours with wet burlap. These specimens were tested at 1, 2, 3, 5, 7, 14, 28, 90, 180, and 360 days, respectively.

Proposed studies in connection with the project include a study of the relative smoothness of the sections and of the influence of different types of joints upon the riding qualities of the surface. A study has also been suggested concerning the load-transferring properties of the longitudinal plane of weakness as compared to the steel center joint.

This report is limited primarily to a description of the project and a brief discussion of the nature of the data obtained during its construction. Later reports will deal more directly with particular phases of the investigation.

Reconstruction of the Old Caribou Road in Canada

An Outstanding Highway Project in British Columbia

By PATRICK PHILIP

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IN the winter of 1924 contracts were called for the construction of portions of the road in three sections—(1) Yale to Alexandra bridge, (13½ miles); (2) Alexandra bridge to Boothroyd, (21 2/3 miles); (3) Lytton to Spence's bridge, (24 miles). The sections from Hope to Yale, (14 miles), and Boothroyd to Lytton, (22 miles), were carried out by the provincial government day labor forces under the direction of the district officials. Since in the Hope to Yale section the existing road, built in 1875, was both badly located, having no fewer than nine grade crossings of the Canadian Pacific Railway, and indifferently constructed, it was practically rebuilt. In the relocation of this 14-mile section only one of these crossings was perforce retained (and even then on an improved location), thus demonstrating the commendable desire of the engineers to make the new highway as safe as possible even at considerably greater initial expenditure. With the "safety first" idea always prominently in view, no fewer than twenty-six Canadian Pacific Railway and ten Canadian Northern Railway crossings were eliminated, and of those remaining, two crossings are overhead, one is a subway and four are protected by automatic safety signalling devices. In constructing this section by day labor the department employed efficient foremen and workmen, chiefly local residents, together with the most modern plant, such as gasoline shovels, compressors, jack hammers, caterpillar tractors, etc.

Section No. 1.—Section No. 1, between Yale and Alexandra bridge, was built by contract in 1925-26 by W. P. Tierney and Company, Vancouver, on a unit price basis. The excavation was classified under solid rock, loose rock, hardpan and earth (or common excavation). The following items were also covered by unit prices: dry masonry, retaining walls, timber cribbing, metal pipe culverts, round log curbing and timber trestles. The specification stipulated that the excavation prices included the loosening, removal and disposal of the various materials comprised in the different classifications together with excavation for cribs, walls, rip-rap, culverts, bridge abutments, trestle bents and galleries. The grading of this section was carried out more substantially than originally intended, timber trestles (previously planned for economy sake), being subsequently replaced by substantial fills. Careful revision of the preliminary survey of this line added over one mile to the length but with compensating advantages in alignment and grades. Being located adjacent to the Canadian Pacific Railway extreme care had to be exercised, one dollar per minute being the penalty for all delays or holdup of railway traffic. Fifteen trains passed daily over the railway, to safeguard the operation of which the telegraph wires were laid in duplex cables at all hazardous points. For the safety of all trains linemen and watchmen patrolled the track throughout the undertaking. A typical view of the rock gallery excavation on this road is shown in Fig. 1.

Fig. 1.—Rock Gallery, One Mile East of Yale

An outstanding example of grade separation can be seen 1½ miles east of Yale, where the highway is carried overhead across the railway at the east portal of the tunnel.

Travellers by the Canadian Pacific Railway will notice that as this section continues westerly the canyon gradually contracts, thereby leaving little room for a road alongside the railway. Consequently careful location was necessary to obviate encroachment on the railway roadbed. Figure 2 shows an interesting and instructive view illustrating this unique feature of construction, viz., river, road and rail approximately paralleling each other. Attention should also be directed to the substantial dry stone wall constructed as a curb at the more dangerous points on the outside of the roadbed.

Work by Stationmen.—Practically all of this section was undertaken by station men, one gang doing 3 miles thereof. The excavation was handled partly with light cars and trucks, and partly by wheelbarrows. Around the first two Canadian Pacific Railway tunnels galleries were cut in the rock (see typical gallery—Fig. 3), and in rock slides care was taken not to disturb "key" rocks. Some of the old retaining walls were used and short stretches of the old road are just as originally constructed, with stones, etc., cleared off the roadbed. Trestles were built between the tunnels at Yale and an unusually long one at Saddle Rock. For surfacing purposes the department was fortunate in procuring excellent limestone gravel adjacent to the right-of-way.

This contract was commenced in January, 1925, and completed in February, 1926.

Inclusive of gravel surfacing, the cost of this 14-mile section average roughly $20,000 per mile, certainly not excessive, considering the comparatively large percentage of solid rock work (about 65,000 cu. yd.), or more than twice the yardage of earth work, the proximity of the operations to the railway, and the hazards thereby incurred.

Unit Prices on Contract Work.—The following is the range of unit prices paid on all the contracts for the Caribou road:—

Clearing	$100.00 per acre
Grubbing	$200.00 to 300.00 per acre
Excavation (200 ft. free haul)	
(a) Solid rock	$1.75 to $2.00 per cu. yd.
(b) Loose rock	0.65 to 0.85 per cu. yd.
(c) Hard pan	0.50 to 0.85 per cu. yd.
(d) Earth	0.30 to 0.35 per cu. yd.
Overhaul	
Per cu. yd. per 100 ft.	0.04 per cu. yd.
Retaining Walls	
Dry masonry	$4.75 to $5.00 per cu. yd.
Cribbing	
Square timber	$40.00 to $50.00 M. ft. B.M.
Metal Pipe Culvert	
12 to 36 in. diam.	$2.25 to $7.55 per lin. ft.
Trestle Bridges	
Square and hewn timber	$55.00 M. ft. B.M.
Curbing	
Round logs	$0.20 to $0.35 per lin. ft.
Tunnelling	$100 per lin. ft.

Alexandra Suspension Bridge.—About 1.5 miles north of Spuzzum the high-

Fig. 2.—View of River, Road and Rail, Between Yale and Alexandra Bridge

way crosses to the east bank of the Fraser river on the Alexandra suspension bridge. This bridge was built practically on the same site as the old bridge but 10 ft. higher, and, therefore, beyond possibility of damage by extraordinary floods. This structure was designed with a view to preserving, as far as practicable, the historic features of the former suspension bridge, but at the same time to provide for modern traffic requirements. The piers and wing walls are of 1:2½:5 mass concrete (aggregating 1,066 cu. yds.), faced with random rubble masonry to harmonize with the scenic setting of this structure. The towers, the tops of which are 35 ft. above the bridge floor, are of reinforced concrete (1:2:4), containing 202 cu. yds. The anchor blocks, rendered necessary owing to absence of stable solid rock anchorage, are of mass concrete (1:2½:5), containing 638 cu. yds.

The main suspension span is 270 ft. long and is supported by eight 2½ in. diameter steel wire cables. The saddles for carrying the main cables on the towers are of the roller bearing type. The span is a steel stiffening truss with a timber deck having a 16-ft. clear roadway. The east approach to the suspension span consists of a 90 ft. steel pony truss, containing 124 tons of steel. The timber deck is finished with a bituminous surface and the timber guard rails are painted white in contrast with the black paint of the steel.

The concrete work was satisfactorily carried out by the A. B. Palmer Co., Vancouver. The Canada Wire & Cable Co., furnished the cables and hangers. The steel was fabricated by Coughlan Steel Works, Vancouver, and erected by the provincial day labor forces under competent supervision. The preparatory work in connection with test pits and foundations was commenced in the middle of August, 1925, and the entire structure satisfactorily completed the following August. On completion of the stiffening truss, the bridge was satisfactorily tested at different panel points with six loaded gravel trucks of 4 cu. yd. capacity (aggregate load 72 tons). As a result of measurements taken during construction of the 270 ft. span, it was possible to determine the total amount of stretch (viz., 15⅝ in.), in the main cables and test of concrete work which was undertaken by a "Little Wonder" mixer should prove instructive:—

Cement

Cement used in 1:2:4 mix.... 6.50 sks. per cu. yd.
Cement used in 1:2½:5 mix 4.80 sks. per cu. yd.
According to laboratory tests, initial set took place in 2½ hours; final set took place in 5 hours; average tensile strength sand briquettes at 28 days, 400 lb. per square inch.

Aggregate

The imported fine aggregate showed a fineness modulus of 2.71; the coarse aggregate 7.22.

Water

The quantity of mixing water used varied somewhat, according to the amount of moisture carried by the aggregates, but it was kept down to a maximum of 4 gal. per sack of cement. After having been analyzed and found suitable, Fraser river water was used.

Results of Tests

Average compressive strength of 1:2:4 mix at 28 days.....2,240 lb. per sq. in.
Average compressive strength of 1:2½:5 mix at 28 days.....2,308 lb. per sq. in.

The total cost of this structure was $101,793.58.

Tunnel Work on Section 2.—The section of the Caribou road from Alexandra bridge to Boothroyd (21-2/3 miles), was undertaken by the A. B. Palmer Co., Vancouver. From the east end of the bridge the road loops up to cross the Canadian National Railway (meantime for economic reasons on a grade crossing which later may be replaced by a subway), and continues above the railway on an entirely new location except for a short stretch at Chapman's station where the old road is followed.

The road climbs gradually to the summit of this section (approximately 1,100 ft. above sea level), where such was the topography that it was imperative to tunnel the gigantic granite rock bluffs with two tunnels, the first 260 ft. and the succeeding one 90 ft. in length, both on tangents. The longer tunnel was made 27 ft. wide and 17 ft. in height, and since both tunnels were bored through hard rock devoid of seepage, it was unnecessary to line them.

Since the tunnels are the only ones forming part of a highway in the Dominion, they are unique in highway construction. Pioneer bores were commenced simultaneously at each end, air compressors and pneumatic rock drills being the only labor-saving devices utilized throughout the operations, which occupied about four months. Much of the rock excavation was hauled to nearby dumps in cars on light rails, but it was possible to use the larger blocks for the dry rock protection walling which formed a special feature of the construction along the rock bluffs in this vicinity. As will be noted from the unit prices previously referred to,

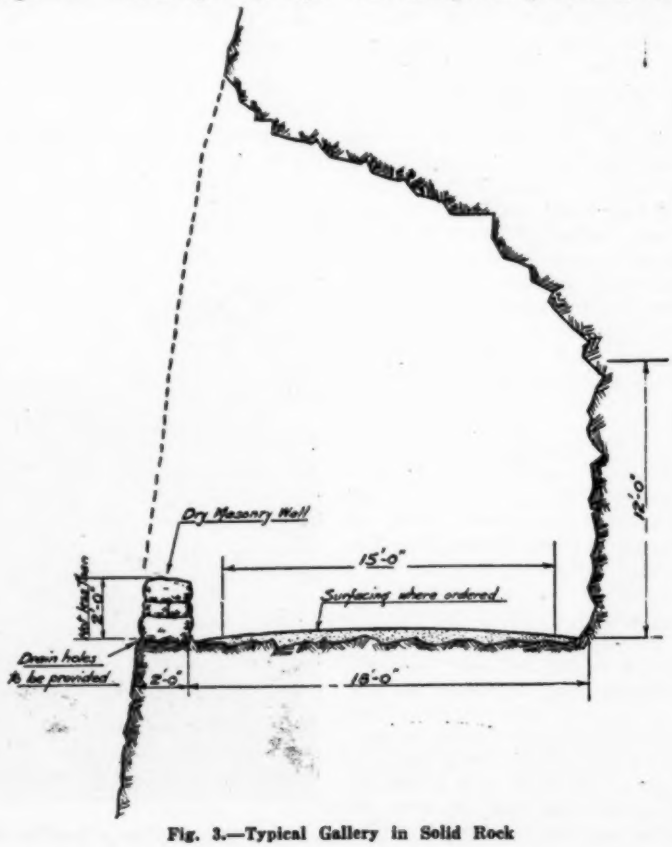


Fig. 3.—Typical Gallery in Solid Rock

the tunnelling was undertaken at a unit price of $100 per lineal foot of cross-section.

After leaving the tunnels the highway continues, in easy and graceful curves, to wind round the rock bluffs, towering over the Canadian National Railway, which at this point is about 600 ft. below the road. Despite the difficult and expensive construction in rock work, the highway was built of ample proportions, the roadbed being everywhere wide enough for two motor vehicles to pass safely, and all curves being widened out and super-elevated. As an added precautionary measure substantial walling (see Fig. 4), about 2 ft. in height and 18 in. wide, was constructed on solid foundations at the outer edge of the roadway, wherever this was deemed necessary. With so much rock conveniently available it was possible to construct dry rock retaining walls of massive blocks, and it is interesting to note that in many places the foundations of such walls were laid directly on the old roadbed and even in some instances on top of old retaining walls, so substantially had they been built in the Sixties. Where rock was not available heavy log protection railing was laid on cradles at the outer edge of the road.

Difficult Rock Work.—At difficult points on this section some splendid specimens of peeled log cribwork can be seen, suitable timber being found nearby. The portion known as China Bar bluffs proved exceedingly hazardous,—certainly the most difficult piece of rock work the writer ever experienced in either railway or road construction. These bluffs overhang the Canadian National Railway tracks some 300 ft. below, while above are menacing precipices. Hence every yard of rock had not only to be laboriously moved by manual methods (exclusive of rock drilling and small shots) but also had to be loaded in cars and hauled to safe dumps away from the railway. The engineering problem was not so much to excavate a roadway round the rock bluffs, but to prevent, or rather hinder, material from the overhanging bluffs damaging either roadway or railway.

Considerable underpinning of the rock above and construction of overhead retaining walls had to be carried out under most dangerous, and, of course, expensive conditions. But, fortunately, this section, unique in highway construction, was successfully and safely negotiated without loss of life or limb, greatly to the credit of the contractors, who had not only to shoulder tremendous responsibility (on one occasion an 11-hour delay of trains due to accidental discharge of rock excavation on the Canadian National Railway involved the contractors in a $2,500 renewal and repair bill in addition to the cost of clearing the tracks), but also the expense bill. The fact that an enormous yardage of rock was laboriously handled in this section, which cost the contractors no less than $76,000 for a distance of 2,260 feet, viz., over $33 per lineal foot, should best demonstrate the difficulties and disabilities under which the work was undertaken over a period of fourteen months.

The view in Fig. 5 illustrates the rugged and diversified nature of the country which this highway traverses, at the same time emphasizing the extreme engineering difficulties to be contended with.

To afford a more definite conception of the magnitude of the operations on this contract, the following is the percentage of classification of excavation:—

	Per cent
Solid rock	35
Loose rock	18
Hard pan	28
Earth	19

Another outstanding feature of the location of this section of the Cariboo road was the diversion round Nine Mile creek, north of Boston Bar. While this added over one mile to the length of the road it resulted in eliminating an expensive high level crossing, about 500 feet in length, paralleling the Canadian National Railway. This diversion further commended itself in the additional scenic features and auto camp sites it rendered available to the motoring public. Nowadays scenic highways are not fundamentally located on the shortest possible distance consistent with negotiable grades.

Cost of Gravel Surface.—The contractors having their organization available, the gravel surfacing between a point 4 miles west of Yale and Boothroyd (36 miles) was carried out by them on the following unit basis:—

Fig. 4.—260 Ft. Tunnel North of Yale

(a) Approved material spread upon the roadbed, as directed by and to the satisfaction of the engineer; free haul three miles; volume of each load to be measured in vehicle of transport at point of loading; cubic yards, more or less. 50,000 at $1.20.. $60,000

(b) Additional payment for each mile or part of a mile over which each cubic yard is hauled beyond the limit of three miles' free haul; cubic yard-miles, more or less. 10,000 at 35 cents..... 3,500

Total (estimated) $63,500

So close was the engineer's estimate that the amount paid the contractors was actually $29 less than this estimated total. Exclusive of bridges, the cost of gravelling worked out at, roughly, $1,800 per mile of 14 ft. width, road centre depth of 4 to 6 in. unconsolidated gravel. Several splendid gravel and shale deposits either in the larger cuts or in pits adjacent to the road reservation were available, but nevertheless the contractor was obliged to haul materials considerable distances.

In several instances it was necessary to screen the gravel through a "grizzly" erected on the roadway, but generally most of the surfacing ma-

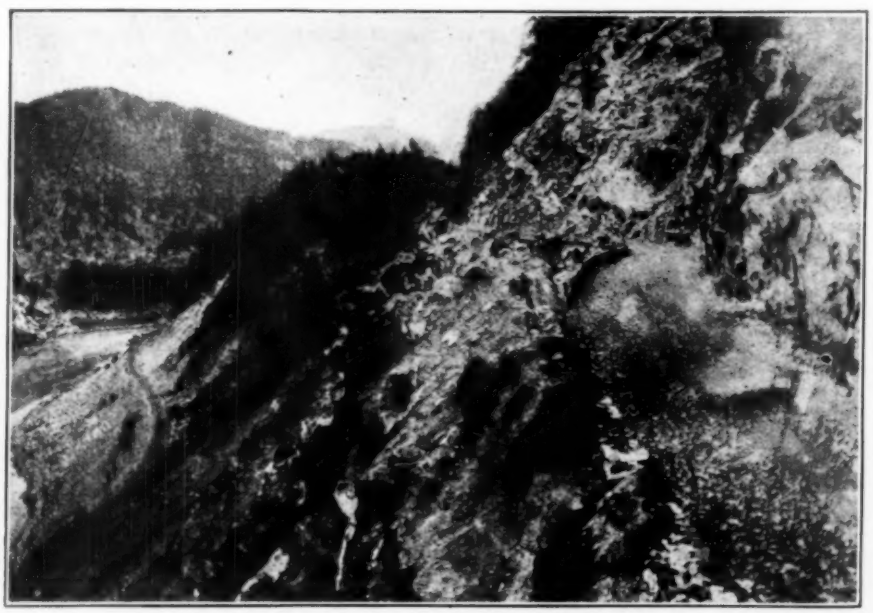


Fig. 5.—View of Road at China Bar Bluffs—With Railway Shown on Lower Level

terial was of such a character as to permit of its being deposited directly on the road. By means of power shovels and 4-yd. truck units it was possible to undertake a considerable yardage daily. The contractors were not required to roll the gravel, but motor graders were employed to grade and shape the road-bed to an even and uniform contour. Since the major portion of the road is built of excellent materials with a large percentage of rock, the nucleus of a splendid gravel surface was thereby procured. Subesquently the surface has been materially improved by the sustained efforts of a special day labor patrol gang equipped with mechanical labor saving outfits.

Here it may be mentioned that immediately after the opening of this highway special maintenance gangs were organized, and outfitted with the necessary equipment to deal with the rock slides, "cave-ins," subsidences and other works contingent to a newly constructed mountain highway. Hence, in the course of maintenance operations the roadbed is being widened, surfaced and otherwise materially improved. On this highway, as on other main highways built out of capital funds, the department has continued its policy of conserving, by careful and continuous maintenance, the original type of construction,—an all-important measure so frequently neglected by highway engineers with detriment to the highway and subsequent greater expense to the treasury.

Bridge Work.—The original road contracts did not include gravel surfacing, as it was deemed advisable to provide for such work in extended contracts after the bridges had been built. Obviously a mountain road of this description necessitated numerous bridges to negotiate the yawning chasms and span the turbulent creeks emptying into the Fraser River with comparatively wide mouths. While the ordinary bridges were undertaken by the A. B. Palmer Company, being built in systematic succession after the completion of the grading, two larger bridges, namely, those at Anderson creek and Stoyama creek, were constructed by separate contract. The illustration (Fig. 6) shows that they were Howe deck timber bridges, that type proving most economical in design and aesthetic in appearance. Spans of 160 ft., having a clear roadway of 14 ft. 8 in., were necessary. Since they crossed rocky canyons at an average height of 160 ft. from the creek bed, naturally their erection demanded an abnormal amount of falsework. The cost of the two bridges in one contract was about $46,000. Coast fir cost $85.00 per M. in place, and trestle approaches and timber piers $22 per M. in place. All the timber bridges are built to withstand a 15-ton concentrated load and have an estimated life of from 15 to 20 years.

Good Work by Contractors.—It is a pleasure to record the generally excellent work undertaken by the contractors, who continuously co-operated with the department's engineers in an earnest endeavor to carry out all work in an efficient and expeditious manner. In the distribution and administration of the necessary construction camps the contractors showed considerable initiative and enterprise, visitors expressing surprise and pleasure at such splendid organization and commissariat. Obviously in mountainous territory with no access roads available the assembling and distribution of plant and material called for considerable labor and ingenuity. On rocky mountain slopes the primitive mode of packing of heavy loads on men's backs had perforce to be resorted to.

Owing to the topography of the country, the ordinary methods of construction of such major highway works, namely, by excavation and other power equipment, had to be dispensed with along rocky mountain slopes. In handling the numerous large boulders and enormous excavated rock work, improvised tripods and hand cranes were used. Air compressors and pneumatic rock drills were also freely utilized to advantage in the abnormally heavy rock work.

So precipitous were the rocky slopes in some sections that the drilling and other work had to be undertaken by men suspended by ropes. Altogether the operations were of an unusual character, calling for resourcefulness and eternal vigilance on the part of the contractors. Consequently it is a fitting testimony to the excellence of their organization and the worth of their superintendents that in a contract of such magnitude involving about a million dollars, there was no loss of life, and even accidents were of minor proportions.

Boothroyd-Lytton Section. — Partly because this 24-mile section involved considerable reconstruction of the old Cariboo road, and partly due to the department's desire to utilize its own extensive up-to-date equipment, it was efficiently and economically carried out by provincial day labor under the supervision of District Engineer Major Taylor, thoroughly conversant with such construtcion work. A half mile diversion involving heavy cuts and fills at Tilton creek was carried out by contract at a cost of approximately $32,000. Other important diversions, to improve both alignment and grades, were carried out by day labor at Kanaka, Falls creek and Cisco. The material handled in those diversions consisted largely of gravel with large round boulders, solid rock and slide rock. On account of the large percentage of rock boulders ploughing was not practicable and some of the hand-moved material cost on an average 50 ct. per cubic yard.

However, the bulk of this grading on this section was carried out by the department's gasoline shovels at from 10 to 14 ct. per cubic yard for earth. Particularly on the side hills, where slide rock predominated, such excavators were found most practicable, economical and expeditious in the widening out of the former narrow roadbed.

In this 24-mile section, which generally traverses, in a winding and undulating manner, the east bank of the Fraser river alternately above the Canadian National Railway and Canadian Pacific Railway, the strategic point is at Jackass mountain, where, after climbing a considerable distance on a 10 per cent grade (the greatest on the whole of the Cariboo road), the highest summit (1,180 feet) is reached.

Since the work at this point was directly over the Canadian National Railway track, heavy blasting was precluded, and practically every yard of rock had to be hauled away, rendering the cost of solid rock excavation about $2.75 per cubic yard.

Some splendid specimens of peeled log timber crib work can be seen at the Jackass mountain summit, where such was the perpendicular nature of the rock that retaining cribs had to be un-

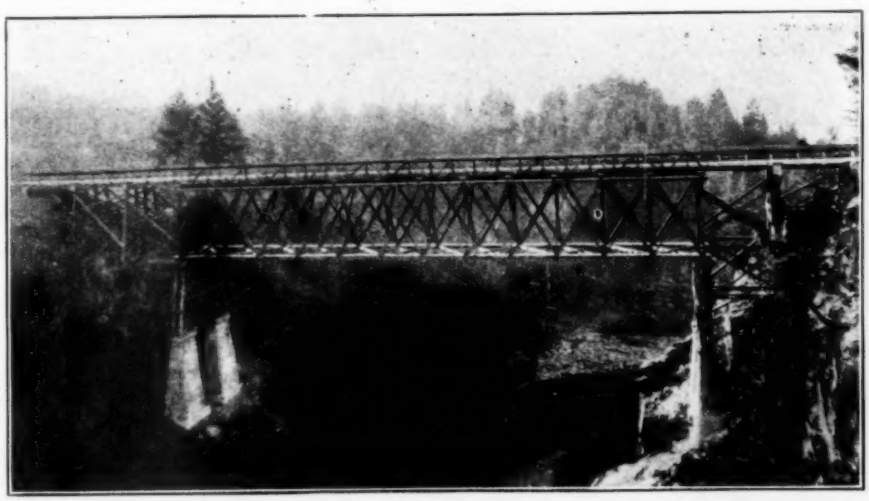


Fig. 6.—Bridge over Anderson River—160 Ft. Howe Deck Timber Truss

dertaken to permit of the standard width of roadbed (16 ft.).

At the east end of Lytton Townsite, where the old road crossed the Canadian Pacific Railway on a dangerous grade crossing, "grade separation" was resorted to. In the entire 24-mile portion there is not a single grade crossing, whereas the old location crossed and recrossed the Canadian Pacific Railway several times. With willing co-operation of the Canadian Pacific Railway company it was possible thus to eliminate all grade crossings, with resultant improvement alignment and grades to the highway generally.

To permit of a necessary revision of the old Caribou road at Cisco, Cisco creek had to be bridged over a rock gorge with precipitous walls. From road level to creek bed is 180 ft. Despite the extremely difficult and dangerous nature of this work and the great expense involved in falsework, the structure was successfully constructed by provincial day labor at reasonable cost ($18,570). The structure consists of one 150 ft. deck. Howe truss span and 80 ft. of trestle approaches all on concrete piers and with a concrete retaining wall abutment at the east end.

Lytton-Spences Bridge.—This is the last section of the Caribou road with which the present article deals. Traversing this territory eastward, particularly for the first time, one is strongly, and even strangely, impressed by the sudden change in the nature of the landscape. Hitherto frowning precipices, the swift flowing Fraser swirling through rock gorges, and sundry cultivated areas, have in succession met the enchanted eye. But after leaving the quaint town of Lytton, situated sentinel-like at the confluence of the Fraser and Thompson rivers, the scenery displays a totally different aspect. Now we are in the "Dry Belt" with sparse timber (chiefly bull pine) and scant vegetation subsisting on the wide sand benches which chiefly characterize this country, but nevertheless with an attraction and charm peculiarly its own.

Throughout its entire length this section of the highway is located on the left bank of the Thompson river, approximately paralleling the Canadian Pacific Railway for the greater part of the distance. For three-quarters of the length the highway route is located well above the railway, but owing to the precipitous gravel slopes (points being designated with the weird names "Indictment Hole" and "The Jaws of Death"), it was imperative to locate the line with extreme care. To do so it was necessary to construct retaining walls adjacent to the railway and heavy rock fills into the river. In loose rock or earth, retaining walls (see Fig. 7 for typical section) had in many places to be constructed. Here also it was possible, by careful revision, to eliminate grade crossings so that in the whole of this 24-mile stretch there are only two level crossings.

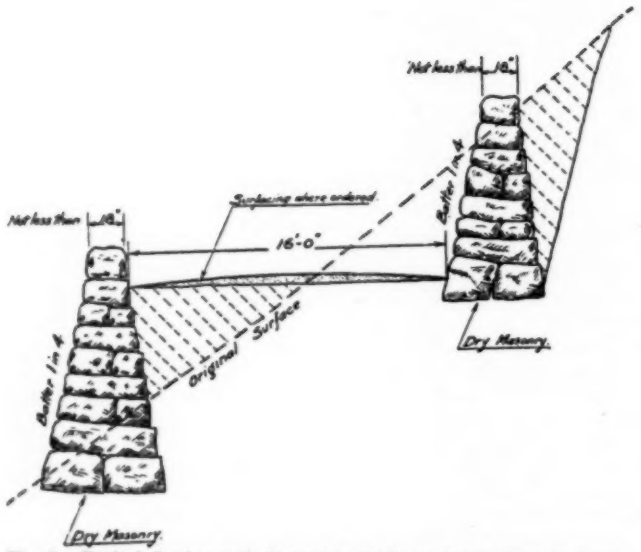


Fig. 7.—Typical Section with Retaining Walls on Loose Rock or Earth

The country between Lytton and Spence's bridge is very rough, and consists alternately of solid rock, gravel and hard pan bluffs with short stretches of flats intervening. The old Caribou road followed the left bank of the river and at various points round the bluffs was cut out of the solid rock or hard pan. The construction of the Canadian Pacific Railway completely destroyed the old road at many points, but particularly where the bluffs come down to the river. On account of the destruction of the old road at these points, in the construction of the new road it was necessary to go over the tops of bluffs, or in cases where that was impossible, to adopt costly and difficult means of construction.

Conclusion.—Inclusive of the Alexandra suspension bridge, the gravel surfacing, and the engineering costs (the latter about 6 per cent of the aggregate), the reconstruction of the 100 miles of the Caribou road, when completed in the fall of 1928, will have cost in the neighborhood of $2,500,000. Considering the enormous difficulties contended with, the abnormal quantity of solid rock, and the excellence of the road work done, an average of $25,000 per mile is quite reasonable.

In conclusion, due credit should be given to those engineers who closely co-operated with the writer in the following work, thereby contributing largely to the success of this undertaking, one of the most important in the highway annals of the province:

Preliminary Surveys: W. K. Gwyer, and F. J. Dawson.
Final Surveys: H. C. Whitaker and R. M. Corning.
Construction Work: Major R. M. Taylor (district engineer at Kamloops), H. C. Whitaker and D. McMillan.
Resident Engineers: F. J. Clarke, T. E. Clarke and G. P. Hayman (deceased).
Construction Work: Major R. M. Taylor and E. H. Verner, district engineers; H. C. Anderson and G. N. Stowe, assistant district engineers.
Bridges: G. M. Duncan, chief draughtsman; A. L. Carruthers, bridge engineer; H. L. Swan and O. W. Smith, resident engineers.

Particularly in the debatable points of location and in the more difficult construction details, great credit is due to G. P. Napier, assistant public works engineer, for valuable advice and assistance.

Reference already has been made to the excellent work of the contractors, but special mention should be made of the willing co-operation of Mr. John Boyd of the General Construction Company (late of the A. B. Palmer Company), and also to that fine veteran contractor, Wm. P. Tierney, who carried out the western section of the canyon work so expeditiously and creditably.

Ackonwledgment.—The foregoing is an abstract of a paper presented June 8 at the Western General Professional meeting of the Engineering Institute of Canada.

Cost of Test Pitting

The following figures in this work are given by E. B. Tourtellot, Assistant Engineer, Wisconsin Highway Commission, in May Bridges Highways:

Last year, a division crew, working in Dane County between July 5 and Nov. 3 put down a total of 1,374 ft. of test and stripping pits. The average cost was $1.63 per foot. If stripping pits are not included a total of 1,068 ft. of test pits were sunk at a unit cost of $2.10. This cost includes labor, supervision, truck mileage, expenses, and depreciation of equipment. The unit cost is somewhat lower than the average for test pitting work in Division No. 1 during 1926. This may be attributed to the following reasons: (1) Short distance to headquarters, (2) Experienced and well organized crew, (3) Summer operation, and (4) New method of removing cribbing.

Material Required By Unit Volume of Concrete

Effect of Voids and Bulking Discussed in Public Construction News

By A. H. HUNTER

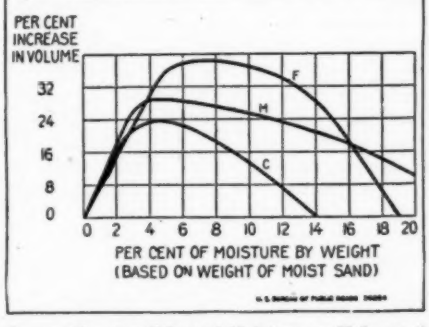
Engineer of Illinois Association of Highway and Municipal Contractors

AT the beginning of each construction season there is opened anew the discussion as to the volume of materials—cement, sand, and stone or gravel—required to produce a given volume of mixed concrete. The engineers in their field work determine by yield test the cement factor or the number of feet, as in the case of pavement work, that each batch of mixed concrete should lay. This work of determining the cement factor is now standarized throughout the State, but the answers are by no means uniform. It seems proper at this time to invite attention to the effect of voids and the bulking caused by moisture, both of which may very materially affect the volume of loose materials required to produce a mile of road.

These two variables, voids in aggregates and the bulking due to moisture, will produce a wide variation in the cubic yards of materials for a theoretical pavement. Again, in producing the theoretical pavement a reasonable allowance must be made for excess material which must be supplied for a slab having a minimum thickness as shown on the plans or cross section.

Voids and Their Effect on Volume of Concrete.—Let us consider the question of voids and their effect upon the resulting volume of concrete. For possibly 25 years the text book of Taylor & Thompson, experimenters and leaders of research in concrete work, has been taken as a basis of construction practice. No doubt the information they have given to the construction world has been of particular value, yet there is no question that the basic knowledge and equipment available for research on concrete work must have been quite limited at the time their studies on the subject were prepared and tabulated. On the basis of information contained in the pages of Taylor & Thompson a tabulation has been arranged for 30 per cent, 40 per cent, 45 per cent and 50 per cent voids assuming the mix of 1:2:3½ ordinarily employed on pavement work. In past practice for several years the 40 per cent voids was taken as a basis for all determinations, consequently requiring 1.61 bbl. per cubic yard of mixed concrete, with a lesser amount of cement in 30 per cent voids and appreciably greater should the voids be 45 per cent or 50 per cent. These figures will indicate at a glance that the cement variation might be more than 500 bbl. per mile of 18 ft. pavement should the voids vary from 30 per cent to 50 per cent. Present practice tries to recognize this variation, consequently the tests as determined by the engineers in the field give varying results even with aggregates supplied from the same pits. You can comprehend that there will be daily variations in the quality of the material produced, also other variations may occur due to stock piling and handling of the materials through the hopper. For a simpler method of noting this vast variation, the Table I expresses it in percentage, assuming 40 per cent voids to be correct and therefore calling it 100 per cent quantity.

PERCENTAGES RETAINED ON STANDARD SIEVES	SAND "C" POTOMAC RIVER CONCRETE SAND	SAND "M" ALLEGHENY RIVER CONCRETE SAND	SAND "F" POTOMAC RIVER ASPHALT SAND
¼ INCH	1	0	0
NO 10	48	13	1
NO 20	70	24	7
NO 30	79	48	19
NO 40	83	68	31
NO 50	88	89	49
NO 80	93	97	70
NO 100	95	98	82
NO 200	97	99	92
PASSING NO 200	3	08	8



Curves Showing Effect of Moisture on Volume of Three Sands

In case the voids range between 30 per cent and 50 per cent the total variations in cement, sand and stone each may be from 15 per cent to 18 per cent. If there were no other factors than that of voids the variation in volume of mixed concrete produced with a given mix would be an appreciable item.

Existing specifications on concrete aggregate permit considerable altitude in range of sizes of material. These limitations have been governed in the past by experience in the field. Practice has proved that materials supplied from many plants will produce satisfactory results if kept within the limits specified. Of course this range from coarse to fine allows a rather large range of materials which might meet specifications. No doubt future development of the mixing of concrete materials will result in a change in specifications in order to take into account the important question of voids.

Influence of Moisture on Volume.—The influence of moisture on the change in volume, especially in sand, is even more important than the influence of the variation in the amount of voids. A large number of tests have been made in the past and the results obtained are well set forth in a bulletin published last season by Mr. A. T. Goldbeck, Director of the Bureau of Engineering of the National Crushed Stone Association. It might be mentioned here that for many years Mr. Goldbeck was with the U. S. Bureau of Public Roads in direct charge of the tests prepared by the government and had access to all of the advantages of the laboratories of the U. S. Bureau.

Within the limits of the specifications ordinarily required for sand suitable for concrete road construction it is not unusual to find a variation of 25 per cent in weight between moist and dry volumes. It is understood that at zero per cent moisture there will be no bulking, but as the percentage of moisture increases the bulking will reach a maximum somewhere between four and eight per cent. As the moisture content increases beyond this point there is a falling off in bulking until the volume is again reduced to the equivalent of that of dry sand. For this reason inundation methods for sand measurement have been recommended and equipment for its practical use is now available.

Attention is invited to the sieve analysis of three sands employed in the research laboratory. The curves on the power portion of the diagram indicate the effect of moisture upon these materials. In general the bulking of sands is much more pronounced

Table I—Effect of Voids on Quantities of Materials

Voids	30%		40%	
Quantities	Cu. Yd.	Mile	Cu. Yd.	Mile
Cement, bbl.	1.49	2,749.51	1.61	2,991.02
Sand, cu. yd.	.42	780.27	.45	836.00
Stone, cu. yd.	.75	1,356.18	.75	1,467.64
Voids	**45%**		**50%**	
Quantities	**Cu. Yd.**	**Mile**	**Cu. Yd.**	**Mile**
Cement, bbl.	1.68	3,121.07	1.76	3,269.69
Stone, cu. yd.	.83	1,541.96	.87	1,616.27
Sand, cu. yd.	.47	873.16	.49	910.31

Note: The above quantities are based on Taylor & Thompson's data applied to our Standard 18 Ft. Pavement. No allowance made for wastage.

Voids	30%	40%	45%	50%
Cement	91.92	100.0	104.3	109.3
Sand	93.33	100.0	104.4	108.8
Stone	92.40	100.0	105.06	110.12

Note: Voids of 40% are taken as standard and the variations for the several percentages of voids are expressed as a percent thereof.

in the finer materials. Coarser sands are not so much affected.

In some measure the presence of moisture has a bulking effect upon coarse aggregates, although not in as marked degree as represented in the sand.

The Illinois Division of Highways in recent years recommended an additional allowance when measured by volume of 15 per cent for bulking of sand; 6 per cent for gravel, and 8 per cent for crushed stone.

Former practice called for computing one bag of cement as .95 per cubic foot. Standard practice now uniform throughout the United States computes a sack of cement as the equivalent of 1 cu. ft. In a general way this allowance for bulking has resulted in an increase in the volume of material that is actually proportioned and goes to make up a batch. Consequently, it is reasonable to expect that the volume of mixed concrete produced is greater than by the old method of bulk measurement.

It might be proper to mention at this time that still more accurate methods of determining the quantities of materials required for a batch of concrete will be applied in the future. Some states are now using measurement by weight with frequent daily changes due to variation of voids, moisture and other factors.

Variations in Cement Factor.—Contractors have frequently invited to my attention vast variations in the cement factor of the same materials when employed on different jobs. A glance over this table of voids and a little thought on the effect of moisture content should make it apparent that wide variation is to be expected.

In known instances the variation occuring in the materials necessary to produce a mile of standard pavement has astounded contractors. In addition to the two variables noted above there is that of the excess volume that must be placed in the road if a pavement of minimum dimension is to be secured at all points. In the season of 1925 the Illinois Highway Department ruled that all completed pavements would be cored by a uniform standard method. Those sections of road 1 in. deficient in thickness would be entirely rejected and the contractor required to remove them and replace with a satisfactory pavement at his own expense. For this variation between standard thickness and 1 in. deficiency the deductions would be made on the basis of the square depth.

As yet here is not uniformity in yield test nor sufficient information available to permit exact determination of the yield of concrete from the many pits supplying material in this state. As a result the theoretical quantities are figured on the basis of Taylor & Thompson 1:2:3½ mix with 40 per cent voids. This is the basis employed by the Highway Department for estimating purposes with a nominal allowance for excess thickness and wastage.

During the last year a complete statement of materials required for varying widths and thicknesses of pavement was published in the columns of this magazine. The quantity of materials as shown was in keeping with the method used by the Illinois Highway Department except that an excess of 10 per cent of the theoretical volume was allowed for excess thickness and wastage. We believe the Highway Department to be within its rights in demanding a certain minimum dimension so long as each and every one of the contractors knows what those dimensions are and that a penalty will be enforced for thin pavement. It sums up that the dimensions shown in the cross section are minimum and you may be allowed to approach that minimum thickness as closely as possible. This assurance of dimension of pavement at all points means that an excess of material on the side of safety must be employed. In other words, you are building a project upon which both surfaces, the top and bottom, are subject to some variation and it is our opinion that a quarter of an inch excess average can be secured only under the best possible working conditions. After periods of heavy rain and forced construction that sometimes takes place in the fall greater excesses are inevitable. Observation of engineers' cross sections on pavement work indicates that an excess of 7 per cent or 8 per cent prevails on the most efficient sections.

At the close of the 1925 construction season C. J. Moritz of Effingham, Ill., prepared a paper, which was read before the American Road Builders' Convention in Chicago, giving information as to excess pavement thickness on both truck and industrial jobs. It is my recollection that some twenty sections selected at random, and without identification, from the files of the Highway Department, indicated no marked difference in the two methods.

Excess Pavement Thickness. — The contractor should be familiar with the methods of the highway engineers in cross-sectioning the work, both before and after placing the pavement, whereby the exact thickness of the concrete is determined at a few stations on each day's run. These engineers are required to keep a daily record and report this thickness to the engineer of construction. This information is collected and included in a report showing the average pavement thickness on each job operating from week to week. Without burdening you with a long list of tabulations we have selected at random ten jobs (see Table II) representing pavement work in five different districts of the state of Illinois, all completed in the same construction week. It seems that the other records for that construction week were about the same as those listed. In comment, however, we believe that possibly the work of subgrade preparation at that season of the year when some outfits were just starting were not quite as good as in the more seasonable months of July and August. It will be realized, however, that a month or two of such percentage as is indicated here would do much to keep up the average for the year.

Table II

Pavement Laid, ft.	Pavement Thickness, ft.	Excess, ft.	Percent	Remarks, Pavement
395	.684	.101	17.3	7-in.
2,214	.614	.114	22.4	6-in.
965	.582	.082	16.3	6-in.
1,106	.557	.057	11.4	6-in.
1,746	.564	.064	12.8	6-in.
1,119	.577	.077	15.3	6-in.
3,986	.460	.043	10.2	5-in.
3.486	.537	.037	7.4	6-in.
1,602	.566	.066	13.2	6-in.
348	.582	.082	16.4	6-in.

In the early part of the season of 1926 there was scarcely a week but found some district with an occasional job running as high as 20 per cent excess thickness. This seemed unreasonable and every effort was made to bring to the contractors' attention this seemingly wanton use of materials. It was kept in mind that these high percentages largely increased the year's average, and if eliminated or decreased should reduce the average materially. We are of the opinion that the average excess for 1926 was greater than that for 1925, even after exercising this care. A general average of these determinations as worked out by the engineers shows that our allowance of 10 per cent for excess and wastage on the aggregates is not unreasonable. Apparently the volume of materials necessary to secure work assuredly within the specifications is not possible of exact determination. The variation in voids of materials as shipped from the plants, the change of moisture content from time to time and the added thickness necessary for a pavement of minimum dimensions present a complex problem.

These questions of voids, bulking and excess thickness have appeared in laboratory reports and have been fully discussed in trade and techincal magazines. Our purpose in this article is simply to point out that they are occurring on ever construction job, and were it not for the fact that many of these variations are compensating and tend to correct each other, the spread in quantities of material would be even greater than experienced. The Illinois State Highway Department is giving the subject considerable attention in its laboratory. The next time your field engineer gives yield tests that have a wide variation be tolerant, for the problem of yield of concrete is not exactly determinate.

National Highway System of France. —The French national highway system comprising 40,000 kilometers of roads is made up of 2,300 kilometers of paved roads, 470 kilometers of concrete, tar, and asphalt roads, and 37,850 kilometers of stone roads.

Principles of Accounting as Applied to Highway Cost Keeping

Paper Presented at Annual Meeting of
the Ontario Road Builders' Association

By W. H. BROWN
Chief Accountant, Ontario Department of Public Highways

TO members of the Ontario Road Builders' Association costs are of the first importance and embrace so many angles that it is almost impossible to tackle them all in one paper. Before touching the actual subject I would like to survey very briefly the situation as I see it.

A contractor may be defined as one who agrees to execute certain work for a secified or definitely ascertainable sum. The work may consist of performing labor alone, or it may include the furnishing of materials as well as labor. The same broad principles of accounting apply to all contractors, regardless of the industry in which they are engaged. It is the purpose here to discuss the principles as they pertain to the accounts of contractors in the road building business.

How an Old Time Contractor Operated.—In recent years great changes have been wrought in the business methods of contractors. In the vitally important department of estimating the contractor of earlier times relied solely on his own judgment, which was formed from personal experience. His work was supervised by practical men, few of whom had the advantage of technical training. In many instances his methods of financing were crude; collections being made from principals who had funds to spare, and payments, other than pay-rolls, being made when there was a surplus of cash. Accounts with principals were considered all important, and constituted the main object of account keeping. Most of the costs were approximated, owing to the absence of accurate cost records. Hence serious deviations from original estimates could not be learned until the completion of the work, and then they could not be traced, nor could responsibility for them be accurately placed.

Operating in this random manner, the contractor made, and lost money, and so long as his competitors operated in the same way and his gains exceeded his losses he was able to continue in business. The large profits made in some instances attracted a new and more aggressive element to the business and competition became keener. The latter-day contractor combined his own technical training with the experience of practical assistants, with the result that estimates were prepared and submitted on a scientific basis. The business of the older contractors declined as a result, and in order to obtain work at all they were obliged to reduce their bids until they found that in the cases where they were successful bidders, losses usually resulted.

Importance of Accurate Costs.—While accurate costs are of great importance to the individual institution, they are of no less importance to the industry as a whole. The manufacturer who obtains contracts by underbidding his competitors, with a price on which he will lose money, not only ruins his own business but destroys that of his competitors. This form of competition is the most dangerous and the most greatly to be feared, since it rests in most cases on ignorance. It is little consolation to the manager whose costs are accurately obtained to see such competitors go into bankruptcy, for, as fast as they disappear, others equally ignorant take their place. Yet this state of affairs is far too common.

In a competition that came under the writer's observation recently, the highest bid was nearly 50 per cent higher than the lowest. After making allowance that the lowest bid may contemplate scant fulfillment of the specifications, and that the highest may be simply hopeful advertising, the only reasonable explanation that can be offered for such a great range is ignorance of basic cost-finding principles. Anyone who has had experience in opening competitive bids will testify to the wide divergence in prices that usually appears in such competition. It for reasons such as these that the intelligent contractor often finds himself confronted with the fact that his bid must be based on market prices and not on his costs. It is no use to bid higher, unless he has a superior article, the merit of which commands the trade irrespective of price. On standard articles the "Trade will not stand" the higher price. Even here his only hope of succeeding is to know the true cost and to try by better building to so reduce it as to leave him a margin of profit.

Furthermore, it is only too often held that cost-finding methods are secret matters that should be kept from the eyes of competitors. No doubt it may be good business policy to keep actual costs secret, but the widest publicity should be given to cost-finding methods if for no other reason than that of educating one's competitor in such methods as shall tend to fair competition. This is now clearly recognized in many fields of industry. The National Machine Tool Builders' Association recognized this important principle some years ago and took active steps toward uniform methods. It would pay all competing industries to do likewise and to publish freely the correct methods by which the costs of their products are obtained. The manager who offered to send his expert accountant, at his own expense, to teach competitors his system of cost finding was a man of keen business ability and not simply a philanthropist.

It is true, of course, that many enterprises make money with the crudest kind of cost-keeping systems, but where such is the case there are always advantageous conditions, the continued existence of which cannot elsewhere be assumed. Many plants, also, make money in spite of antiquated machinery and methods, either because of local advantages or because lack of competition allows large profits. Strong leadership may often compensate for material disadvantages, but such favoring conditions may not be so easy to maintain in the future. As industry grows, competition becomes ever keener in all branches of life, with the consequent requirement of a more exact knowledge of the details of business. And, as any enterprise increases in size the methods based merely on personal observation become increasingly inadequate.

Why There Are Many Failures.—A grocer who fixed the selling price of sugar with reference to that of his competitor, and not with reference to what it had cost him, would be considered as having adopted a decidedly unsafe policy. And yet this is a common method of fixing prices in the manufacturing field. Many manufacturers often persist in paying dividends out of capital simply because they do not know what their selling price ought to be, but have fixed it either by that of some competitor or by some rule of thumb. Enterprises of this kind collapse like houses of cards when dull times arrive, and constitute, no doubt, a large proportion of the four-fifths of the failures which are due to personal incompetence. Accurate knowledge of the cost of production is an absolute necessity, and the detail in which it is required to know these costs grows daily with the growth of enterprises, the increase in

competition and the development of new methods of management.

Each business requires individual study. It is obvious also that no particular cost-finding system will apply to all forms of industry, since industries vary so widely not only as regards the character of the work they are conducting, but also as regards the manner of their organization. The information that the cost system should gather, and the manner in which this information should be presented, will also vary widely in different enterprises. The cards and forms which are admirable for one kind of work are useless, therefore, in others. The general underlying principles of cost finding are, however, universally applicable, and if the principles are clearly understood there is seldom any difficulty in developing cards and forms suitable to the work in hand. Many good suggestions can be obtained by a study of the blanks and forms found in current practice, but the presentation of too great a variety of such documents tends to obscure basic theory.

Estimating Cost of Production.—In estimating the cost of production there must be considered not merely wages and material, interest and rent, repairs and renewals, but in addition some allowance must be made for the diminished value of the fixed assets due to gradual loss of serviceability. Consequently, profits are not determined until after allowance has been made for depreciation. Depreciation is not a disposition of part of the profits, but an expense without which profits can never be earned. The principle is clear. Materials consumed in manufatcuring a commodity, as for instance fuel or oil, are, of course, an element of expense. This is so because an item of wealth disappears, and its effect can only be to diminish the net wealth. Its loss is, in other words, an expense. In the case of fuel the loss is immediate, and is, therefore, charged at once to expense. Exactly similar is it with the productive instruments whose use extends over a longer period. The article consumed in a single use must be considered an expense of the current production, the temporary structure or the tools lasting only a year are charged against the production occurring during the year. The more permanent form of assets serving for productive use during a period of years should be spread as an expense during the period of use, whether that be five or fifty years.

The immediate effect of allowing for depreciation is properly to equalize profits during different years. Otherwise the total cost of the machine must appear as an expense of the year when it finally proves unserviceable. At that time, its value ceasing, it can no longer appear in the inventory. The amount of goods on hand being thus diminished, there must needs be a subtraction from the profit and loss, or other proprietorship account. But if the original value of the discarded machine, say $20,000, was continued on the books throughout its entire life of 20 years it may roughly be said that the proprietors in the last year showed an excessive loss of $19,000, while the proprietors during the preceding 19 years overestimated their profits by the same amount. Such a procedure is improvident where there is no change in proprietors or stockholders; it is inequitable where the personnel has changed; in all cases it is dangerous to the creditors who, up to the last year, have not been shown the true condition of the company's assets.

Depreciation should cover all decline in value due to the use of productive assets. Not less than this is required by accounting prudence. But while this standard is frequently not reached, it is not unusual to find corporations charging to depreciation sums far in excess of the actual decline in value. Yet such excessive depreciation offends the very principle of accounting. To charge too much to depreciation is no less a deviation from accuracy than to charge too little. Yet the two transactions are very differently regarded by the public and by the profession.

To charge too little is considered dishonorable; to charge more than enough is considered a sign of conservatism, but where this occurs the action is very frequently praised by the financial writers.

The effect of excessive depreciation is to conceal the amount of profits, to create what is known as a "Secret Reserve." Depreciation is normally charged to expense or at least to Profit and Loss. If, in fact, there has been no actual decline in value, the result is that the balance sheet shows an understatement of both assets and profits. The questions involved are, therefore, those of undervaluation of assets and secret reserves. It suffices to call attention to the fact that an excessive depreciation, while generally condoned, is still a divergence from an ideal accounting, and its effect is the establishment of a secret reserve.

Causes of Depreciation.—Causes of depreciation may be generalized under three heads:—Wear and tear, obsolescence and inadequacy. The specific causes are very numerous, and there are many factors affecting its rapidity and extent. Among these are:—Quality of construction, adequacy to meet future demands, method of operation, repairs and renewals, climate, etc. In case of such intangibles as patents, copyrights, and leaseholds, progress of depreciation may usually be assumed to be in direct proportion to expired time. Matheson gives the following causes of depreciation:

1. Wear and tear.
2. Tenure of holding.
3. Permanency or steadiness of industry.
4. Exhaustion of raw materials.
5. Obsolescence due to new inventions, new product, or better ways to make the same product.
6. Troubles and catastrophes not insurable.
7. Fluctuations in trade.
8. Inadequacy.

Destruction is the law of nature. Even so-called permanent improvements, such as buildings, are all subject to ravages of time, which Marshall aptly defines as "The complex of destructive agencies." All machinery is on an irresistible march to the junk heap, and its progress, while it may be delayed, cannot be prevented by repairs.

This obvious economic fact is of momentous import to accounting, although full recognition has not been given to it in general practice. It implies that, in valuing all fixed assets, account must be taken of the lapse of time, and even in the case of machinery giving no evidence either of use or misuse, the basic fact that it is a year nearer its inevitable goal, the scrap heap, is an item of which technical account must be taken.

The mechanical aids used on each contract vary from all hand tools to large machines, such as steam shovels, hoisting machines, pile drivers, cranes, etc. In order that the general office may know at all times the location of such equipment it is desirable that a complete record of each item be kept, and an account opened for each large piece of machinery and group accounts for the smaller pieces. This record should contain full particulars of the piece of equipment and care must be exercised to see that the cost includes every item of expense which enters into the laid down value. A favorite omission in this respect is the handling charges for unloading the equipment when this is not included in the purchase price.

Now let me point out that one of the most important points to be taken into consideration in figuring your costs, and the one that is most frequently neglected, is that of depreciation. It should be kept very clearly in mind that depreciaton is always an expense. No job should be estimated without proper regard to the depreciation of the equipment involved. Always remember also that your equipment is depreciationg in value, whether it is being used or not.

Overhead Costs.—We now come to what is perhaps the outstanding item in estimating the cost of any job, i. e., burden or overhead. There are a very large number of items that enter into the overhead costs of the contracting business, some of which can very easily be overlooked, but it is well to bear in mind that these very items will perhaps make all the difference between profit and loss. Never neglect to take into consideration depreciation on your equipment, depreciation of your offices and furniture, salaries and expenses of your office staff, interest on overdrafts, interest on your loans, insurance and workmen's liability charges, taxes, in fact every item of expense that can-

not be applied to a specific job is an item of overhead. The time of the man who writes the pay checks for the head office is as much a charge to overhead as the foreman's time is a charge to the job he is engaged upon. Every job you estimate on must bear its portion of these costs in order that you can be assured that your figures are as nearly correct as an estimate can ever be. More contractors have gone to the wall through leaving out overhead charges than from all other sources combined.

A very important matter in the administration of the contracting business is a proper cost accounting system. It must be realized that if you have the exact cost of a job you are in a much better position to estimate on any future work of a similar type than you would be without it. Cost accounting records need not be cumbersome, in fact the simpler they can be made the more successful they will be. Keep the cost of each job separate and do not forget that it is not complete without its share of overhead. Also remember that the charges for moving your equipment to the ground must always form a portion of your costs.

If you sublet any portion of the contract keep proper records of this portion of the work, because after all you are responsible.

Contractors' accounts to be effective should at all times show the cost to date of all work in progress and provide the means of comparing these costs with the estimated costs used in the preparation of the bid, and also with the contract price of each subdivision. Information should always be available as to the amount of money drawn and what hold back is retained by the principal. The cost records should be so constructed as to disclose the profit and loss on each subdivision of the work. The general ledger accounts should be so arranged to supply readily the data required for statements of actual assets and liabilities and of profit and loss.

Sealed Felt Base for Concrete Pavement

A test section of concrete pavement, incorporating what is known as the Monolite process, was constructed recenty near Milpitos, Santa Clara County, California. The immediate purposes in building this test pavement were to determine best methods of procedure and to compare costs, strength and uniformity. In order to make these comparisons alternate sections were laid with and without the Monolite base. This work was described in the May issue of The Highway Engineer by W. C. Hammatt, Consulting Engineer, San Francisco, Calif. We quote from his article as follows:

The Monolite process consists of laying on the subgrade a dampproof base consisting of shingled layers of an asphalt-impregnated felt sealed with a brush coat of hot asphalt. The advantages claimed for this base are (1) to preserve the integrity of the concrete by preventing the change of water-cement ratio which frequently occurs in concrete laid directly on porous dry soil, and (2) to break the bond with the subgrade and permit free movement between expansion joints.

Recent published tests of cores on Wisconsin and Missouri jobs have shown a variation of strength on the same job and the same specified mix of more than 60 per cent above and below normal. This variation does not appear to that degree in separately cast cylinders, thus showing that it is due largely to conditions of laying the slab. It is believed that by this method of laying, in what amounts to a watertight form, unaffected by conditions of moisture or chemical salts, laboratory conditions will be more nearly established, yet without material increase in the cost.

The slab was 11 ft. wide, part of a widening project, and 7 in. thick, with an outer-edge thickness of 9 in. Expansion joints were placed every 60 ft. with dummy joints at 20-ft. intervals. Each slab was separately reinforced with two deformed bars, one above the other, on all four sides.

In constructing the slab, the gage rail, consisting of an inverted 4-in. channel carried on a milled 2 by 4 timber supported by stakes driven into the subgrade, was placed prior to the completion and acceptance of the grade. Excavation was carried about 6 in. below the base of slab and the space was refilled with selected, imported material. This was rolled and afterwards bladed to about ¾ in. below the specified subgrade, filled to grade with sand, and struck with a template.

Conclusions.—Beam tests of specimens previously made have shown an improvement of about 15 per cent in the modulus of rupture by the use of this base, but no core tests have yet been completed. The following observations, however, can be made from this project:

(1) Under the adverse conditions occurring on this job, where the grade was obstructed by reinforcement and gage rail supports, the base can be laid faster than concrete can be poured —the use of Monolite will not be a factor in slowing up construction.

(2) The water cement of the mix (5-bag) can be reduced at least ½ gal. with equal workability where the dampproof base is used.

(3) The elimination of loss of concrete in the wet earth subgrade, amounting often to 4 to 7 per cent, together with the saving of labor and water for wetting the subgrade, partly offsets the cost of the base itself.

The contractor on this project was the Allied Contractors, Inc., of Omaha, Neb., and the Monolite base was laid by the Monolite Co. of America, of San Francisco, Cal.

Second Pan American Road Congress

The program and regulations for the Second Pan American Road Congress to be held June 19 to July 3 inclusive, 1929, in Rio de Janeiro, have just been approved by the Minister of Transportation.

The program calls for discussion of a variety of subjects: methods of construction and conservation of roads, circulation, exploration, legislation, administration, finances and economics, international and Pan American agreements, propaganda, education, and other themes.

The regulations of the congress which have for their object the choosing of methods and systems and the coordination of forces concerned with the construction, exploration, conservation, and financing of roads, determine that the congress shall be constituted of the representatives of the republics of the Pan American Union and of those private associations and companies who have obtained admission. The former —that is, the official members,—will have voice and vote in all sessions and will be invited by the Brazilian Government to take part in all acts, excursions and festivities of the congress. The adhering (unofficial) members can take part in the sessions, with the right to speak, but without the privilege of voting. All will present their credentials to the committee on organization of the congress (Commissao organizadora) before the date of the preliminary session, all requests for inscription by adhering (unofficial) members being required before March 1, 1929.

When convocated opportunely, the official members will unite on June 19, 1929, to elect the president and executive committee of the congress.

The Second Pan American Road Congress will hold two plenary sessions, one at the opening and the other at the close, besides other ordinary sessions to deliberate on the proposals presented.

Except in the case of a special resolution of the assembly, no speaker will be permitted, while discussing the same subject, to have the floor more than two times, and at each time he will be allowed ten minutes. All papers presented must be in Portuguese, Spanish, English, or French, with 10,000 words as a maximum for any paper, and all papers must be accompanied by a resume not exceeding 1,500 words, written in the language of the original paper, with a translation of the resume into Portuguese.

All papers must be presented in triplicate to the committee on organization (Commissao organizadora) before March 1, 1929, in order that the committee will have time to decide whether the respective papers may be presented at the sessions of the congress.

Portable Sheds Permitted Continuance of Concrete Pavement Construction During Heavy Rains

A shed system of laying concrete was an unique feature in building the last unit of the Volcano Road, on the island of Hawaii. The need for some kind of cover was apparent because of the incessant rains, hence this was developed.

The road from Hilo to the mouth of the crater of Kilauea Volcano, was one of the most interesting jobs under recent construction in Hawaii. It ran from the 3,600 ft. elevation to about 4,500 ft. elevation at the edge of the crater, and was of the best American made concrete.

The total shed covering was 350 ft. The first section was built high enough to allow the mixer to work under it, and had a clear lonitudinal span of 50 ft. to allow the surfacer to work. The other sections each about 30 ft. long, were lower.

Satisfaction with the shed system was expressed by Frank West, manager and general superintendent for the Hawaiian Contracting Co., on the island of Hawaii. He said only two days were lost on account of rain.

The contract price of the Hawaiian Contracting Co., of Honolulu, who had general charge of the work was $318,-000. The total length of the last unit was 6½ miles and 9,500 cu. yd. of concrete were laid.

The larger shed is run on rails which also make the forms for the concrete. This is used as a cover while the concrete is being laid. The smaller portable sheds are used for curing.

The Land Leveler as a Medium of Earth Transportation in Sub-Grade Construction

Method and Costs of Tractor Handled Equipment on California Job

By W. H. BALLARD

Superintendent of Construction, Santa Fe Land Improvement Co.

DURING the season from January, 1928, to the present time, July, an extensive road construction program has been in progress on Rancho Santa Fe, Cal., for the purpose of opening up new subdivision units.

The specifications called for subgrades varying in width from 18 ft. to 24 ft., to be paved or surfaced, with bordering walks and parkway areas. This necessitated preliminary rough grading of roadways ranging from 24 to 50 ft. in width. Construction has been conducted on a force-account basis under the direct supervision of the Santa Fe Land Improvement Co.

The Equipment. — Equipment was rented from U. L. Voris, a general contractor of San Diego County, and consisted entirely of Best caterpillar tractors with Holt and Throop land levelers (sometimes known as ground planes), Russell graders, Killifer sub-soilers and Towner sub-chisels. At the peak of the program two Best-60's and two to three Best-30's were used, but for the greater portion of the work one '60 and two '30s have been able to keep sufficiently ahead of water main and electric conduit installation. The '60s use Holt 5.0 cu. yd. capacity and Throop 3.5 cu. yd. capacity levelers, Killifer 3-standard subsoilers and a Russell super-special grader. The '30s use Throop 2.5 cu. yd. capacity levelers, Towner sub-chisels, Killifer 1-standard subsoilers and a Russell standard No. 3 grader. For the construction of bordering parkways and walks, a 2-ton Holt or Cletrac with a 1.5 cu. yd. capacity Schmeiser leveler and a Fordson-powered 1-man grader will be used. The operators of all these units have been exceptionally proficient men and deserve great credit for the type of work accomplished. The standard working days are 9 hours, but during the peak of the work this was increased to 10 hours.

General Conditions.—The earth encountered ranged in workablity from a fine loam, through sandstone and decomposed granite to clay and adobe. Since much of this work was carried on in late winter and spring, the soil conditions retarded progress appreciably.

Road lines were engineered to follow as nearly as possible the natural contours, avoiding through cuts where possible. However, much of the country worked through was extremely rugged and necessitated heavy cuts and fills. Grades varied from 2 to 9 per cent. Cuts ranged from 3 to 15 ft., and fills from 3 to 20 ft. As it is a policy of the Santa Fe Land Improvement Co. to mar and deface as little as possible the slopes bordering their roadways, side borrows were prohibited. This policy made necessary the complete construction of roads from material within the roadway limits, and led in some cases to dirt hauls up to 750 ft. in length.

How the Data Were Collected.—Having used heretofore only teams and team equipment in the construction of roads, terraces, drains and the like, the writer was most anxious to make unit cost and efficiency comparisons between this type of equipment and tractor hauled levelers. As the work progressed therefore, daily observations and records were made and rechecked as to time, cost, yardage loaded and yardage delivered over station distances. Since much of the material was moved during the wet months while in a condition which with team equipment would have been considered as almost unworkable, it was possible to obtain a very wide and varied assortment of data. When these data through repeated checking in the field appeared truly representative for the different types of equipment used, in various earth conditions, unit curves were plotted, as shown.

Unit costs are not given, as equipment rentals vary greatly in different localities, and such figures might prove misleading. By applying local equipment rates in terms of cost per minute of operation to the graphs given, the unit cost of earth transportation may readily be reached. Individual results may be obtained by applying the formula:

$$C=\frac{S \times T}{E}$$

in which C=Cost Per Cubic Yard Delivered

S=Cost Per Minute of Operation

T=Time Elapsed Per Load Delivered in Minutes

E=Cubic Yards Delivered

If the above formula is used, great care should be taken not to assume that the result obtained is representative, but several experiments over equal distances should be observed for a true average. Since the curves have been obtained through repeated experiments, they are perhaps more safe to use in estimating costs. Even allowing for the wide average of results from which the graphs are derived, it is well to add from 10 to 12 per cent for a safety factor to results shown by them. This will usually cover loss of time from delays, minor breakdown, etc.

Curves Based on Transportation.—It must be borne in mind that these results are based solely on transportation of earth in construction, and costs derived therefrom would not include the loosening of earth with a plow, scarifier or subsoiler, nor the blading of the roadway with a grader. In other words the leveler couples the functions of an immense fresno with those of rotary scrapers, wheelers, and in exaggerated cases, of dump wagons, and with the added advantage that the leveler constructs as it travels, constantly planing slight elevations and filling small depressions. However, as a means of conveying earth en masse over considerable distances where spill might be unnecessary or undesirable, as to a waste dump, or through city streets, the leveler would not be practical, as with dry soils there is always a certain loss in transit due to the inequalities over which it travels.

Another point to be remembered in applying the accompanying curves is that they are based on complete cycles of haul and return. They could not be accurately applied to a series of pick-ups and dumps with intervening empty hauls, excepting to show yardage delivered over stated distances. Such a condition embraces so wide a range of factors that to present it graphically would be impractical.

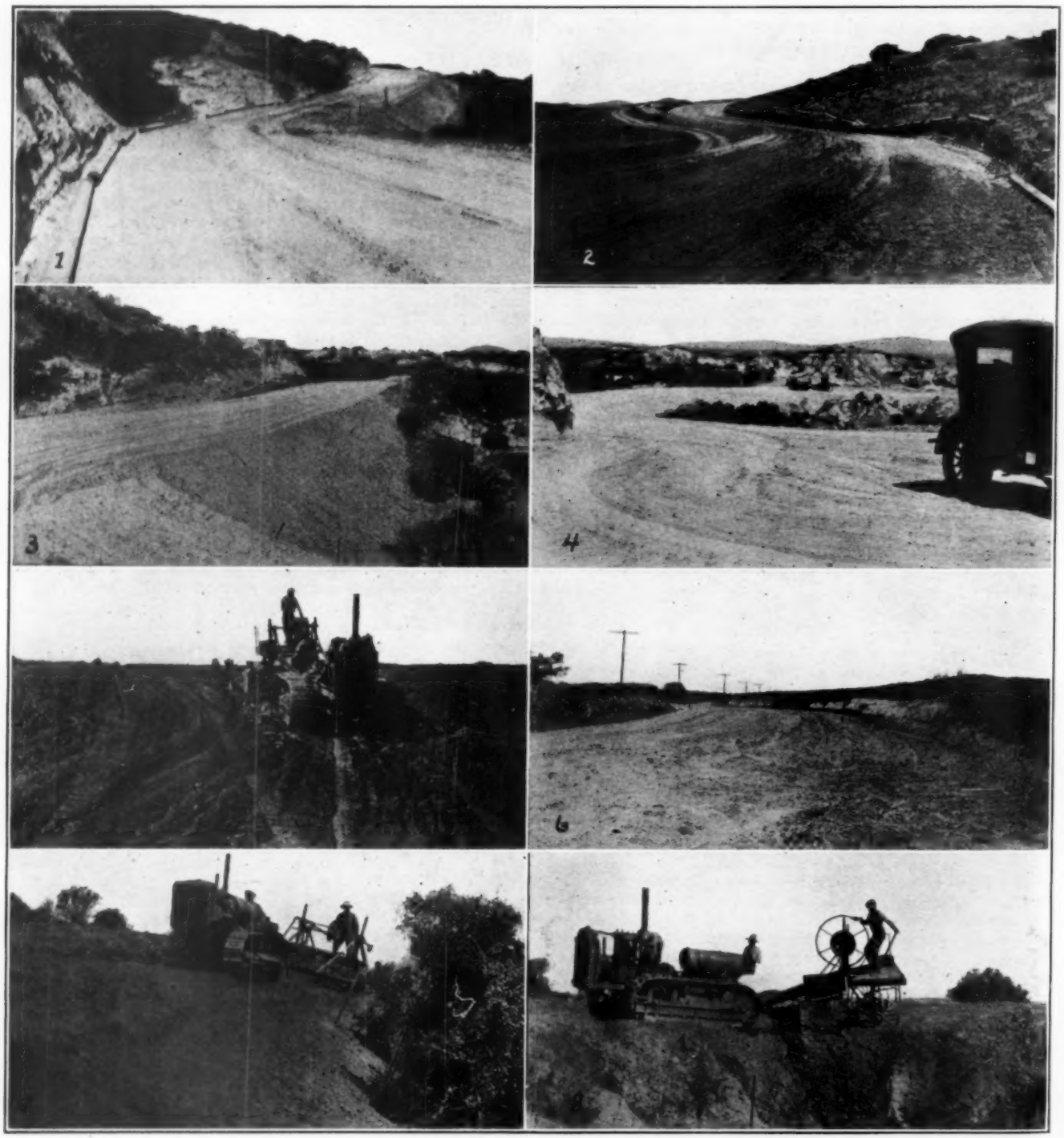
A distinct advantage over fresnos lies in the leveler's ability, especially the larger types, powered by a '60 or similar tractor, to maintain a more level plane of roadway during construction, thus giving an easier and more economical finish. Perhaps this will conflict with the observation of other construction men, but such certainly has been the writer's experience.

Operation of Levelers.—With skilled operators it is quite simple to construct embankment with the leveler without "breaking-over" with the load. By its ability to waste smoothly when desired, it eliminates much of the lack of uniformity and undulation to bank-edges so tedious to remedy.

The weight of any of the larger types

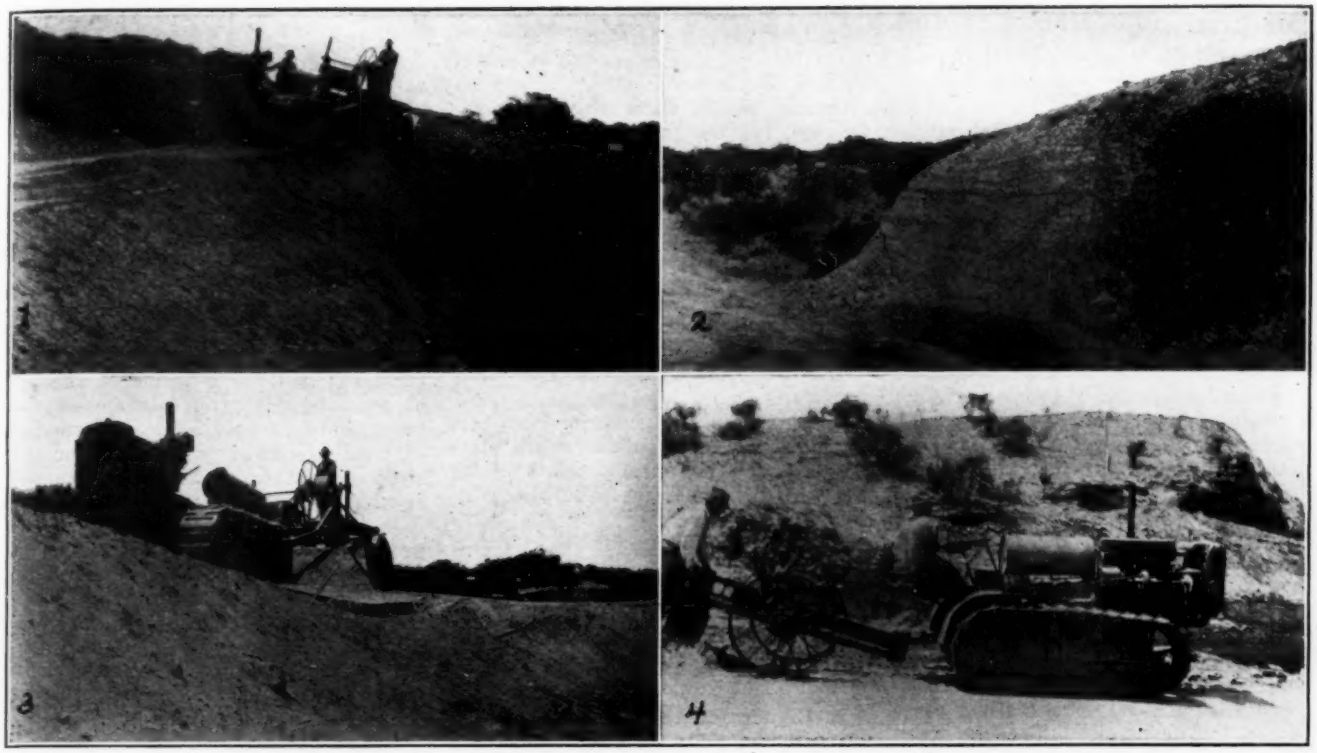
of leveler is such that its blade will bite deeply into firm earth, or partly broken stone, saving much loosening with plow or scarifier. Particular mention is made in this respect to the 5.0 cu. yd. type, though good results were had with the Throop 3.5 cu. yd. implement. The latter was found slightly more retentive of earth on long deliveries (400 to 550 ft.), due, perhaps to the more curved construction of its pan.

Turning area is of course an important consideration, both in time and convenience. More particularly is this true of the '60 and large leveler. This type of equipment must either find a location in the roadway or adjacent to it, wide enough to execute a full circle (a diameter of 40 ft.) which in precipitous country is often difficult, or it must "back and fill." It was found more



Examples of Completed Roadway Built with Tractors and Levelers Together with Construction Views

(1) Completed 30-Ft. Roadway Ready for Pipe Installations; Built at an Average Cost of $0.56 Per Lineal Foot, or $0.186 Per Square Foot, or $0.25 Per Cubic Yard; Hauls Ranged from 50 to 500 Ft. (2) Completed 34-Ft. Wide Subgrade Ready for Pipe Installation; Average Cost $0.30 Per Lineal Foot, or $0.009 Per Square Foot; Constructed by '60 Tractor with 5 Cu. Yd. Levelers and '30 with 2.5 Cu. Yd. Leveler; Other Views of the Work on This Section Are Shown in Illustrations (1) and (2) on the Following Page. (3) A Completed Section of Cut and Fill; Maximum Cut 12 Ft., Maximum Fill 16 Ft.; Built by '60 and Levelers at a Cost of $0.13 Per Cubic Yard. (4) 30-Ft. Roadway Built at a Cost of $0.38 Per Lineal Foot, or $0.0126 Per Square Foot or an Average of $0.16 Per Cubic Yard; This Was an Unusually Advantageous Piece of Cut and Fill Work. Well Balanced and with Hauls Not Exceeding 250 Ft.; Other Views of This Section Are Shown in Illustration (3) and (4) on the Following Page. (5) Start of 6-Ft. Through Cut with '60 and 3.5 Cu. Yd. Leveler for 30-Ft. Roadway. (6) Same Location as (5) Showing Completed Through Cut; Slopes Made with Back Sloper on Russell Super Special Grader. (7) Constructing a 12-Ft. Fill with Best-30 and 2.5 Cu Yd. Throop Leveler. (8) '60 and 3.5 Cu. Yd. Leveler Wasting Over Fill for Bridge Approach



General Construction Views of Grading Operations with Tractors and Levelers

(1) Fill Being Constructed by Best-60 and Holt 5 Cu. Yd. Leveler. (2) View of Same Work Shown in (1) Looking West Showing 15-Ft. Vertical Cut Construction by '60 Tractor with Leveler and Blade. (3) Best-60 and Holt 5 Cu. Yd. Leveler Preparing to Waste Over Fill. (4) Best-30 Subsoiling with Killifer Subsoiler.

economical to travel empty a distance of 150 ft. to another pick-up than to "back and fill" once. The Best-30 and its equipment can of course turn in so short a radius that loss of time in that respect is not a factor.

The constant "K" appearing on curves represents the total turning time elapsed in one complete round trip, averaged from more than two hundred observations under differing conditions.

Length of Economical Hauls.—From the graphs it would appear that:

(1) The Best-30 and 2.5 cu. yd. leveler is not economical for deliveries exceeding 250 ft.

(2) The Best-60 with either a 3.5 cu. yd. or 5.0 cu. yd. leveler attains its maximum efficiency in hauls over 100 ft. and up to 400 ft. in average dry soils.

(3) The Best-60 with a 5.0 cu. yd. leveler, transporting damp earth, is not efficient under 250 ft., due to slow pick-up of load, but will deliver more yardage from 450 ft. to 750 ft. than it will with dry soils, due to better cohesion of damp earth particles.

Comparative Costs.—From careful observation and comparison of parallel cases the writer is convinced that under average workable conditions, where borrows or wastes are not too far located from the work, subgrades such as commonly cost from $2,000 to $3,300 per mile when built with team equipment may be constructed for from $1,800 to $3,000 per mile through use of caterpillar tractors with land levelers for transporting earth in construction.

28,538 Miles of Improved Roads to Be Built in 1928

Forty-five state highway departments will construct 28,538 miles of good roads during 1928, according to the American Road Builders' Association. Both states and counties are now in the midst of the most elaborate road construction program in history, it is stated.

Three states have not reported their official programs. They are Connecticut, Virginia and West Virginia. It is believed that these three states will add at least 1,000 miles to the year's state highway program. The number of miles under construction on the county system is not known.

Expenditures during the year will total approximately $1,307,821,000 in the 46 states reporting their estimated appropriations for both county and state work. Connecticut and West Virginia did not report. The total expenditures during 1927 for all states was $1,123,607,055, or $184,216,661 less than will be expended in 46 states during 1928.

"Not only has the good roads movement expanded considerably during the present year," the American Road Builders' Association states, "but the work which is being done is much better and much greater than ever before. This is the result of more scientific construction and maintenance methods and improved road building machinery and equipment.

"Thorough studies of road building and maintenance methods have greatly reduced the costs of good roads. The annual convention and road show of the American Road Builders' Association which will be held in Cleveland next January is expected to bring to light many new scientific improvements destined to decrease construction costs and increase efficiency even more than during the present year."

The association pointed out that the cost of good roads this year will be less than eight-tenths of one cent for each mile traveled by motor vehicles, and that a good road saves from 2 to 3 ct. per mile in cost of vehicle operation.

Maine State Highways Being Cleared of Advertising Signs.—A drive is now being made by the Maine State Highway Police to clear the advertising signs off the highways. Four years ago the legislature passed an act which prohiibted the erection of advertising signs on the public highways. These signs had become obstacles to automobile drivers and greatly marred the landscape. Many of the signs were replaced on private property, but the majority of them were never put up again. The law applies not only to signs which are strictly of an advertising character, but also to private signs directing to camps and hotels.

Compression, Flexure and Tension Tests of Plain Concrete

The strength of concrete in bending and direct tension is an important element in the design of concrete roads. An investigation made for the purpose of determining the effect on the flexural and tensile strength of plain concrete of some of the factors which are known to influence the compressive strength, was described by H. F. Gonnerman, Manager Research Laboratory of the Portland Cement Association and E. C. Sherman, Assistant Engineer of the laboratory, in a paper presented at the recent meeting of the American Society for Testing Materials. The tests formed a part of the experimental studies on concrete and concrete materials being carried out at the Research Laboratory of the Portland Cement Association, Chicago. The following is an abstract of the paper.

Synopsis of Tests.—Parallel compression, flexural and tension tests were made at ages of 3 days to 1 year on specimens molded from the same batches of concrete. The variables studied included: Quantity of mixing water, quantity of cement, size, grading and type of aggregate, age at test, curing condition, and size and length of tension specimen.

Compression tests were made on 6 by 12 in. cylinders and flexural tests on 7 by 10 by 38 in. beams loaded at the third points of a 36 in. span. Tension tests were generally made on 6 by 18 in. cylinders; a few tests were made on cylinders of other lengths and diameters. Special grips were employed to hold the tension specimens during loading.

The tests show that the relations between water-cement ratio and the modulus of rupture and tensile strength of plastic workable concrete mixes are similar to the water-cement ratio—strength relation for compression tests, showing that for given materials and methods of manipulation the water-cement ratio is a governing factor in the strength of concrete whether tested in compression, flexure or tension. Typical age-strength relations were obtained with each of the three types of test. An advantage was shown in all three types of testing in the use of a low water-cement ratio in the production of high early strength concrete.

Uniformity of Tests for Field Control.—In recent years considerable interest has been shown by engineers in the development of a type of test convenient for field control of concrete quality. On road construction the beam test is becoming more generally used than the compression test and is believed by some engineers to give more uniform results. A study was made of the uniformity of strengths for the different types and conditions of test employed in this investigation. In this study the uniformity was judged by the mean variations—the mean of the variations of the individual strengths from their average expressed as a percentage of the average.

On the whole, there was little difference in the uniformity of the strengths obtained in the three types of test. The compressive and flexural strengths showed about the same degree of uniformity, which in a few of the tests was somewhat better than that of the tensile strengths. In general the mean variations for each of the three types of test for the other variables studied were:

1. Somewhat higher at the early ages than at the later;

2. Appreciably higher for the dry, non-plastic concretes than for the plastic, although the mean variations for the very wet concretes were also relatively high;

3. Somewhat higher for the lean than for the rich mixes;

4. Essentially the same for workable mixes in the tests where the size and grading of the aggregate was varied (average mean variation for each type of test about 5.0 per cent); and

5. Higher for the tension test of 2 by 6 in. and 10 by 30 in. cylinders than for the 6 by 18 in. cylinders.

The higher variations obtained in the tension tests of the 2 by 6 in. cylinders were due mainly to the fact that the sensitiveness of the testing machine would not permit of very accurate tests at the low loads sustained by these cylinders. The 10 by 30 in. cylinder was rather bulky and unwieldy and test conditions were not quite as favorable for this as for the 6 by 18 in. cylinder.

Conclusions.—The principal conclusions from the compression, flexural and tension tests are as follows:

1. The relations between the water-cement ratio and the modulus of rupture and tensile strength of plastic, workable concrete mixes are similar to the water-cement ratio-strength relations for compression tests, showing that for given materials and methods of manipulation, the water-cement ratio is a governing factor in the strength of concrete whether it be tested in compression, flexure or tension. Increasing the amount of mixing water reduced the strength for all three types of test, the effect being relatively greater on compressive strength than on either the modulus of rupture or tensile strength,

2. Typical age-strength relations were obtained with each of the three types of test. The strengths of moist-cured concrete in all cases increased with age. Compression and tension specimens cured in air of laboratory after 1, 7 and 28 days moist curing, increased in strength up to about the 3-month period and showed little or no increase thereafter, whereas for these methods of curing the modulus of rupture continued to increase with age. The longer the period of moist curing before removal to the air of laboratory, the higher were the strengths at the later ages.

3. A feature of the tests was the advantage shown, by all three types of test, in the use of a low water-cement ratio in the production of high early strength concrete. Reducing the water-cement ratio not only increased the strengths at the later periods, but also greatly increased the early strength so that it was a much higher percentage of the later strength.

4. The tests show that such factors as size and grading of the aggregate affect the compressive and tensile strengths and the modulus of rupture of concrete of a given mix and consistency, only as they affect the amount of water required to produce the desired consistency. The strength increased with the size of the aggregate and also with increase in the proportion of coarse to fine so long as the proportions of coarse to fine did not result in an undersanded mix. For increase in the coarseness of the grading into the range of undersanded mixtures, the compressive and tensile strengths dropped off sharply, whereas the modulus of rupture continued to increase. In view of these results it would seem that flexure tests for field control of concrete quality should be used with some caution, particularly with coarsely graded aggregates, since tests of undersanded or honeycombed and porous concrete might through the higher flexural strengths indicate a better quality of concrete than was actually being obtained.

5. There were well-defined relationships between the compressive strength, modulus of rupture and tensile strength of moist-cured concrete made from Elgin sand and gravel. The relation between the modulus of rupture and the tensile strength was practically constant. The relations of these strengths to the compressive strength were not constant but were nearly so at the higher strengths. The modulus of rupture of concrete having a compressive strength of from 2,000 to 5,000 lb. per sq. in. ranged from about one-fifth to one-seventh of the compressive strength and the tensile strength from one-tenth to one-twelfth of the compressive. This shows that the tensile strength was about 0.5 to 0.6 of the modulus of rupture.

6. Similar well-defined relations between the three types of test were found for the few coarse aggregates other than Elgin gravel included in the investigation. Except for the soft sandstone, the relations for the other coarse aggregates were very nearly the same as for Elgin gravel.

7. The tensile strength was not appreciably affected by either the length or size of the cylinder.

8. In general, there was about the same degree of uniformity in the strengths obtained with the three types of test.

Building a Motor Highway From Florida Mainland to Key West

How Road Was Built Over Florida Keys, Told in Du Pont Magazine

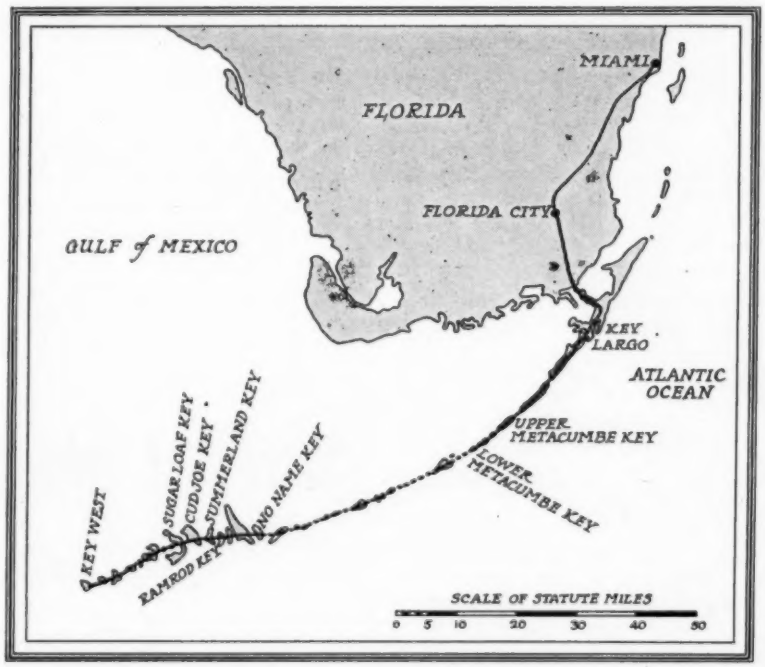
By T. M. GARRETT

ONE of the most remarkable road-building projects ever undertaken in the United States was the construction of the Oversea Highway in Florida. When completed it will extend from Florida City, on the mainland, to Key West, the southernmost point in the United States.

This highway stretches across the Florida keys and runs parallel to the famous "Oversea Railroad" throughout its entire length with but two notable exceptions. The first deviation occurs at Upper Metacumbe Key, where the highway crosses the railroad, and the second at Sugar Loaf Key, where the railroad is crossed for the last time.

Highway Built on Islands.—Probably no other highway in the United States presents so many unique features as this one. Imagine, if you can, a road running for a distance of about 130 miles over a series of eighteen small islands, the largest of which is not more than twenty-eight miles long and the smallest not more than one and one-quarter miles long. On one side these islands are bounded by the Atlantic Ocean, and on the other side the Gulf of Mexico stretches to the far horizon. In many places the islands are so narrow that a clear view of both the gulf and the ocean may be had by a motorist driving along the highway. At other points the road is actually carried by means of fills or bridges across some portion of each of these bodies of water.

Formation of Islands.—To get some idea as to the manner in which this highway was constructed, it is desirable to have some knowledge of the formation of these islands or keys, as well as the topography of the country through which the road was built. A key, as defined in this section of Florida, is a coral island, varying in size from 200 to 300 ft. long by 50 to 100 ft. wide, up to 28 miles long by two to three miles wide. Very few of these keys are more than 3 ft. above sea level, and at high water some of them may be entirely submerged to a depth varying from 6 to 12 in. The coral rock of which they are composed varies in hardness as well as in composition. It is of limestone formation, containing from 70 to 90 per cent lime, and is so soft in some places—especially under water—that it may be dug after "dobying" with 60 per cent straight nitroglycerin dynamite; in other places, under the same conditions, it resembles blue flint and is exceedingly difficult to drill as well as to blast. Any person knowing the formation of the Florida keys would naturally think they would be barren of plant life. But, astonishing as it may seem, the opposite is



Map Showing Location of Oversea Highway

Clearing Trees, Brush and Weeds from Right-of-Way by Means of Dragline

Hauling Rock on Large Fill Connecting Upper and Lower Metacumbe Keys

true. These small limestone islands are literally covered with vegetation, in some places so thick as to be almost impenetrable. On these keys are raised some of the finest limes in the world, and cocoanut palms flourish and bear in profusion.

General Features of Highway.—The road across the keys is 16 ft. wide with 4-ft. shoulders. It is, of course, built on solid rock due to the formation of the keys, and has a 12-in. coral rock base, with 4-in. top course. This road is of the oil-penetration type.

There will be in the completed highway about 105 miles of road and altogether 26 miles of bridges. At present there has actually been complete 80-odd miles of road and 7 miles of bridges, which leaves a gap of about 40 miles between No Name Key and Lower Metacumbe Key. The county has closed this gap temporarily by ferry service, having in operation two large ferry boats, which are entirely adequate to handle all traffic for the time being. It is intended, however, as soon as the money is available, to close this gap permanently by constructing about 22 miles of additional road and 18 miles of bridges, one bridge of 14 miles and two bridges of 2 miles each.

The Contractors.—All of the completed highway, including 14 bridges and 80 miles of road, was under contract to three principal contractors: Jenner Brothers Construction Co., Davenport, Ia., had projects four, five and eight, extending from the upper end of Key Largo to Lower Metacumbe Key. S. J. Groves & Sons Co., Minneapolis, Minn., had projects seven and nine, which take in all of Sugar Loaf Key up to and including No Name Key. And the Tidewater Construction Co., Key West, Fla., succeeded by the Key West Construction Co., had projects one, two and six, which included a stretch from the mainland to Key Largo and another section from Sugar Loaf Key to Key West. The Oversea Construction Co. has also done work on the Oversea Highway, some of it as sub-contractor under the Tidewater concern, and a three-mile stretch under direct contract from Monroe County.

Bridge Construction.—Contracts for the fourteen bridges were distributed between the three principal contractors; S. J. Groves & Sons Co. having the greatest number, six in all. These bridges are of wooden construction and are all of the four-pile standard trestle type. They vary in length from 60 to 6,500 lin. ft., and are so placed as to be at least 5 ft. above high water. Below each bridge the average depth of water is about 3 ft. to 4 ft. The bridge piles are driven into the coral rock bottom from 4 to 5 ft. This insures a solid foundation for each bridge. It is almost impossible to pull out one of these piles after it has been placed, due to the peculiar gripping action of the coral rock. Completed, the bridges have an actual running surface 15½ ft. wide, are equipped with a very strong guard rail on each side, and have a short approach at both ends, in some cases approximating a 12 per cent grade. It is estimated that the life of this particular type of bridge is about 12 years.

Drilling in an Ocean Pit Near Islamorada, Metacumbe Key

Construction Difficulties.—As may have been expected, many difficulties were encountered by the contractors who undertook the work of constructing the Oversea Highway. Every conceivable kind of road-building equipment had to be procured and brought to the job, such as gas shovels, draglines, pile drivers, dredges, motor trucks, winches, hoists, drilling outfits, motor launches, barges, scrapers, graders and the like. In fact, there is probably no other single highway project in the country which required a wider range or variety of equipment than was needed for this one.

In addition to equipment troubles, and the problem of securing and holding labor—and it was not an inconsiderable task in view of the isolation of the jobs and the mosquito plague which is prevalent on all the keys, especially during the summer months—each contractor has had more or less serious trouble with his drilling and blasting. Probably the main difficulty was due to the inability to get an efficient drill rig, but no small part of it was caused by inefficient blasting devices and unusual resistance on the blasting circuit.

General Construction Procedure.—To understand how some of these difficulties arose, it is necessary to know something of the general procedure fol-

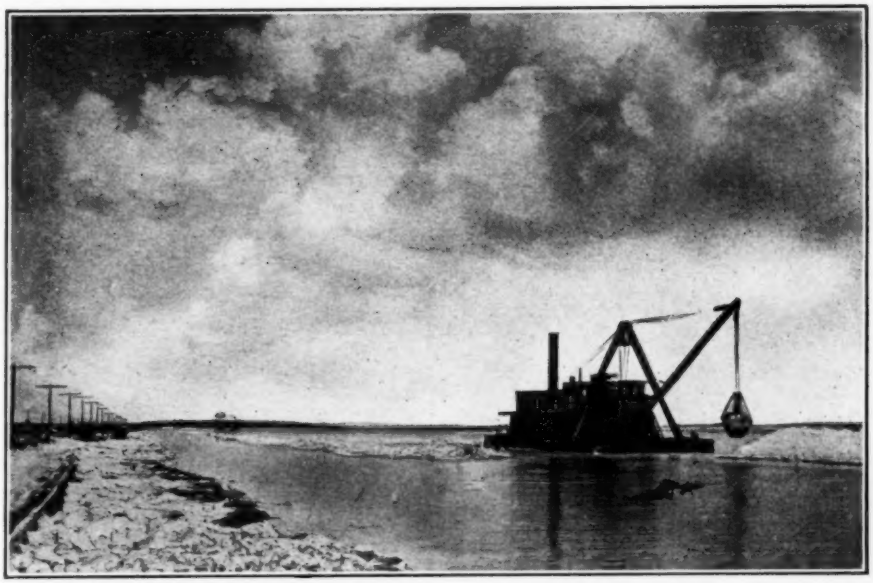
Scarifying Rock, Forming Base of Road and Preparing Surface for Top Material

lowed by the contractors in the construction of the road. On those keys —or any particular section of the key —that are high and dry, the right of way is first cleared of the thick vegetation by means of a dragline which pulls out the trees, brush and weeds and exposes the coral rock. This is then scarified, and prepared for the surface rock.

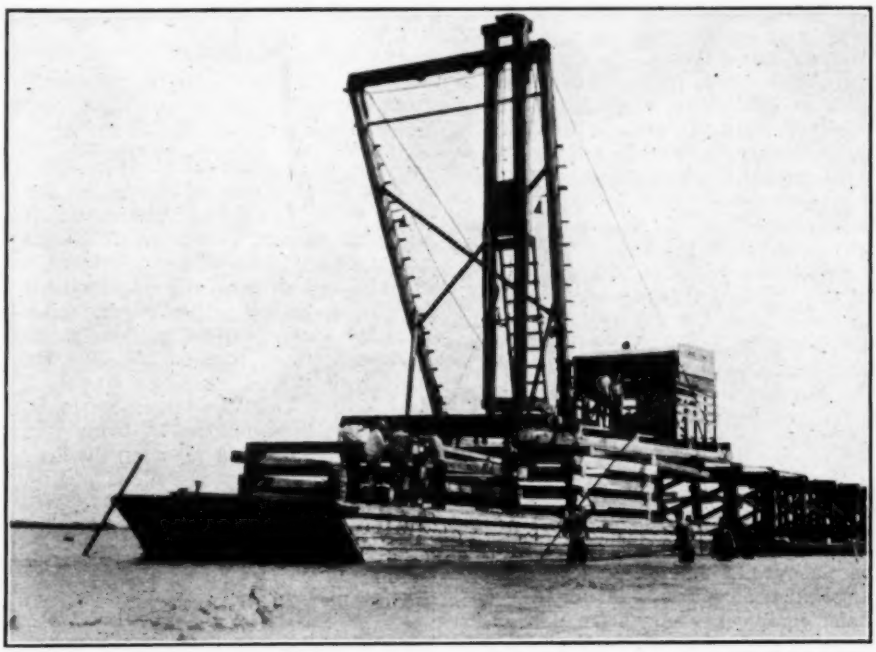
In some instances this rock is obtained along the right-of-way by means of drilling and blasting on either side of the proposed road. The blasted rock is then thrown by a dragline or shovel into the roadbed and spread out to the desired width and depth. Where this method can be followed the contractor saves considerably in time as well as in labor, as he handles his rock only once and is not put to any additional expense through having to haul it from some distant point. In getting rock in this manner the contractor generally makes a cut from 8 to 10 ft. wide and about 10 ft. deep along one side of the road. This cut as a rule follows the course of the road completely across the key and connects with open water at both ends so that a small canal is formed which serves to drain the road as well as the surrounding key.

Ordinarily, constructing a drainage canal of this kind would be looked on with favor, and in some sections of southern Florida the practice is followed quite generally, but this is not true on the keys to any great extent. In many cases they are so low that the water would back up from the ocean or gulf into these small canals, and the road would be flooded instead of drained. Again, if there were not a good flow of water through a canal, it would serve as an excellent breeding place for mosquitoes, which is very undesirable. For these reasons the contractors working on the keys, with some few exceptions, were forced to use ocean rock obtained along the edge of the keys rather than rock obtained along the right-of-way.

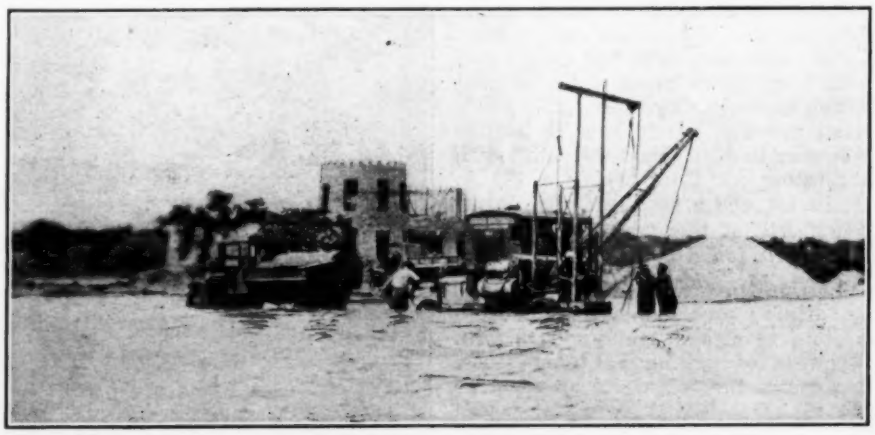
Hand Drilling Ocean Rock.—It was in drilling and blasting this ocean rock that the contractors experienced most of their difficulties. Up until the time work was started on the Oversea Highway, it had been the general practice in southern Florida to employ negro labor to put down holes in the coral rock. From 10 to 50 negroes were employed, depending upon the size of the operation. Each negro was equipped with a 1½-in. iron pipe, and he literally punched a hole in the rock by lifting and dropping the pipe with his weight behind it, until a hole of the desired depth was made—usually 10 ft. During this operation the negro turned the pipe slightly to the right or left, when dropping it, and from time to time poured a little water into the hole to keep the pipe cool and also to soften the rock. Some of these negroes could drill as much as 300 lin. ft. a day, and



Dredge at Work Close by the 2-Mile Marl Fill, Which Extends Between Upper and Lower Metacumbe Key



Pile Driver at Work on Road Between Summerland and Ramrod Keys



Procuring Rock from Ocean Bed

Section of Completed Highway Between Upper and Lower Metacumbe Keys

as they made from 3 to 4 ct. a foot, their average daily pay might run as high as $12. This method of drilling was very satisfactory, particularly in Dade County, and was continued there until competitive conditions in the rock business forced the introduction of cheaper methods. It was not, however, so successful on the keys, where it was necessary to drill and blast ocean rock. In this work the driller was compelled to stand in salt water from 2 to 3 ft. deep, and in some places where very hard rock was encountered, he could not put down the holes at all, or, at the most, could not drill more than 30 ft. of holes.

Machine Drilling.—In looking around for a more satisfactory method of drilling, it was finally decided to use a paving breaker and a solid hexagonal steel bar about 15 ft. long made of drill steel and absolutely flat at the end. This equipment had been used with some success in a few of the rock pits near Miami and it was thought that it would work here. It proved to be only moderately successful, however, due to the fact that if anything larger than 1¼-in. steel was used, the drill would stick when down about 4 ft., so that it was impossible to remove it without blasting. The result was it became necessary to supplement this outfit with a rotating air drill, taking a 1½ to 1¾-in. bit, and after some experimenting, a drill of this type was obtained, and it was found to be satisfactory.

Blasting Operations.—The solution of the drilling problem enabled the contractors to make rapid progress with the work of getting out ocean rock. In some of the ocean pits as many as 100 to 150 holes, 10 ft. deep, spaced on 7 to 10-ft. centers, were fired daily. These holes were generally loaded with 1¼x8-in. cartridges of 60 per cent straight nitroglycerin dynamite, but in some instances ⅞-in. cartridges were used, depending upon the choice of the contractor who did the work.

This blasting was, of course, all done under from 2 to 3 ft. of water, varying with the tide at the time. Naturally, unusual resistance was encountered on the blasting circuit, caused undoubtedly by the corrosive action on the blasting caps of the sea water, which ranges in temperature from 60 to 70°. This resistance caused no little trouble at first, especially in the larger blasts, but it was finally overcome by firing from the 100-volt lighting plant on the draglines, and by using 32-volt naval storage batteries. With these devices, from 75 to 100 holes, spaced on 5 to 7-ft. centers and connected in parallel series, were detonated without misfires.

In constructing the portion of the highway that has been completed, approximately 500,000 lb. of du Pont dynamite was required. About 95 per cent of this was 60 per cent straight nitroglycerin dynamite and the remainder 60 per cent gelatin. The straight dynamite seemed to be the best powder for this work, due to the porous nature of coral rock, and it was also less expensive than gelatin because of its higher cartridge count.

Highway Opened in January.—The Oversea Highway was formally opened to the public on Jan. 25, 1928, when ferry service between No Name Key and Lower Metacumbe Key was put in operation. The opening of this highway enables the motorist to travel from Miami to Key West, a distance of 160 miles, over one of the most unusual highways in the world. It also connects at Key West with a beautiful six-mile boulevard which encircles the eastern portion of the island, and eventually it will throw open to the tourist the whole wonderful system of highways now under construction in Cuba. More than 700 miles of paved road may be reached from Key West by a mere 6-hour ride on ocean-going steamers that are fully equipped to handle automobiles as well as passenger traffic to Havana and return.

Highway to Cost $15,000,000.—In estimating the completed cost of the Oversea Highway, it has been variously figured at from fifteen to sixteen millions of dollars. This includes the cost of erecting the 14-mile concrete bridge and the two other bridges of two miles each that are necessary to close the water gap where the ferry boats now operate. These bridges alone will probably cost $13,500,000 and will be constructed eventually by means of state and Federal aid, as the county is not

Finished Section of Road Crossing Key Largo

now, and may not soon be, in a position to finance these projects.

Just when the Oversea Highway will be entirely finished is rather indefinite at this time, but the two years consumed in bringing it to its present stage of completion have been well spent and speak well for the resourcefulness of the people of Monroe County. The entire project, with the exception of a few miles in Dade County, was financed by the citizens of Monroe County without state or Federal aid, and it was due to the progressiveness of these people, as well as to the active and intelligent supervision of J. N. Watkins, chief engineer, and his assistant, Clifton G. Bailey, that this highway has finally become a reality and, as such, the southernmost link in the famous Dixie Highway.

Michigan Maintenance Forces Mark Danger Spots on Roads

All hills and curves on the trunk line highway system of Michigan are being marked in a distinctive manner. The work and its purpose are explained in the following letter sent by B. C. Tiney, Maintenance Engineer of the State Highway Department to the Division Engineers:

"Regarding special yellow centerline marking on blind curves and hill tops. Section 15, paragraph B of the uniform traffic act reads as follows:

"The driver of a vehicle shall not overtake and pass another vehicle proceeding in the same direction upon a grade or upon a curve in the highway unless the driver's view along the highway is sufficient to insure safety."

"Governor Green is much interested personally in the placing of special yellow marking on blind curves and hill tops to assist the state police in stopping the practice of cars passing each other in these blind areas. It is the desire of the State Highway Department to make a careful and complete job of this special yellow centerline marking. A yellow centerline paint, which has a very satisfactory service record in the state, is being ordered for immediate delivery to counties. A shipping list is being attached to this letter for each maintenance supervisor, showing the quantities of paint being shipped to each of his superintendents.

"This special marking is to be placed on all hard surfaced roads including bituminous treated macadam and gravel. It is to be placed on all horizontal and vertical curves on hard surfaced roads where traffic does not have a clear view of 500 ft. or more. The length of the yellow line to be placed on curves will, of course, vary with the local condition. Perhaps the clearest way to instruct your superintendents in this matter is to say that the yellow line shall be continued around a blind curve or over a blind hill top to a point where traffic has a clear view of 500 ft. or more ahead, and there stopped. The superintendents and maintenance supervisors should give considerable personal attention to establishing the proper limits of these yellow lines and traffic in both directions should be considered in fixing the termini of these lines. The simple case would be a hill top with a sharp crest in which case you would simply have 500 ft. of yellow line each side of the crest. If the crest is not sharp but has a flat portion on top of more than 500 ft. in length, your yellow marking would not be continuous across this long flat top because there would be a safe passing area on this flat top.

"On non-central jointed pavements you will instruct your superintendents to discontinue the regular black or white centerline marking used on straightway when they come to the areas to be marked with special yellow and have only the yellow marking in such areas. On widened horizontal curves without central joint you will spot your yellow centerline so as to give two-thirds of the widening to the outer half of the curve.

"On central jointed pavement we do not believe it would be advisable to place the special yellow line right over the central joint because the black joint filler material would possibly discolor the yellow and make it ineffective. We believe that the best way to handle this situation is to place the yellow line to one side and adjacent to the joint filler material. This would make it slightly off center but not enough to materially affect traffic. I am advised by our Design Engineer that the present practice in construction of concrete curves is to place the central joint in the middle all the way around the curve. We believe that it would be confusing to attempt to give two-thirds of the widening to the outer half on jointed pavement, as this would create two centerlines an appreciable distance apart and we will therefore lay the yellow line just alongside the central joint on these curves.

"Our standard width for yellow line as well as for black and white line is four inches.

"Hand marking machines are being provided by the department for those residences having an appreciable amount of this marking to do. In some residences where there are only a few scattered locations to be marked, the centerline can be worked out by some hand painting method, devised by the superintendent."

Unprotected Grade Crossings Increase

A study of grade crossing accident statistics in preparation for the work to be done by the Grade Crossings Committee of the County Officials Division, has just been completed by the American Road Builders' Association in cooperation with the Interstate Commerce Commission.

It was found that 206,533 unprotected grade crossings existed on class 1 steam railroads alone at the beginning of 1927, while the number of protected clossings totaled only 27,747. Of the protected crossings, 6,148 were guarded by gates, 7,760 by watchmen, 6,427 by audible and visible signals, 5,308 by audible signal only, and 2,204 by visible signal only.

During 1927 persons killed at grade crossings totaled 2,371 and the injured 6,613. No reports of accidents or the number of unprotected grade crossings on electric or oil railroads was available, although the association hopes to have such report available within a short time.

A table showing the number of unprotected grade crossings in each of the states and the number of casualties occurring in each follows:

State	Total deaths	Total injuries	Unprotected crossings
Alabama	34	143	4,125
Arizona	9	28	958
Arkansas	23	91	4,251
California	118	330	6,254
Colorado	24	48	2,766
Connecticut	10	23	461
Delaware	7	29	251
Florida	34	125	4,682
Georgia	36	137	5,080
Idaho	9	16	1,838
Illinois	205	567	2,376
Indiana	188	431	7,977
Iowa	35	148	1,035
Kansas	55	241	1,386
Kentucky	48	119	2,883
Louisiana	41	84	3,161
Maine	11	13	905
Maryland	20	38	815
Massachusetts	22	55	708
Michigan	118	388	8,261
Minnesota	35	101	8,117
Mississippi	52	123	2,783
Missouri	44	142	7,242
Montana	4	33	2,268
Nebraska	23	56	6,657
Nevada	2	5	432
New Hampshire	12	21	702
New Jersey	89	206	1,667
New Mexico	9	19	940
New York	193	452	5,024
North Carolina	33	113	4,687
North Dakota	10	32	5,629
Ohio	300	619	9,673
Oklahoma	41	141	7,285
Oregon	16	29	1,723
Pennsylvania	139	434	8,425
Rhode Island	1	6	58
South Carolina	11	69	3,544
South Dakota	13	23	4,626
Tennessee	43	122	3,958
Texas	86	350	11,771
Utah	4	24	1,491
Vermont	10	33	468
Virginia	49	71	3,518
Washington	20	73	3,596
West Virginia	22	55	2,196
Wisconsin	63	206	7,075
Wyoming	.....	1	588
District of Columbia	.....	.....	22
Total	2,371	6,613	206,533

Demurrage Charges

General Features That Highway Contractor Should Know Discussed in Northwest Associated General Contractor News

Demurrage is a penalty charged by railroads for detention of freight cars.

Free Time.—Every shipper and receiver of freight is entitled to a reasonable time within which to load or unload a car. Rules of the carriers uniformly allow 48 hours for that purpose and this allowance has been held reasonable.

Allowance of Additional Free Time.—There are, however, circumstances under which it is impossible to release cars within 48 hours and an additional time is allowed. For example, the condition of the weather may be such as to make it impossible to remove the freight from cars without serious injury to the freight; sand and gravel, etc., may be frozen and it may be impossible to remove it from cars by ordinary methods; floods or snow may make it impossible to reach a car and unload it within the 48-hour period, or, as the result of the act or neglect of the carriers, cars originating at the same points, moving to one consignee at one point may be bunched in transit and tendered by the railroad in accumulated numbers in excess of daily shipments. Under such circumstances additional free time is allowed, provided a claim is made in writing to the carrier within 30 days from the date the demurrage bill is rendered.

Charges.—At the expiration of the 48 hours' free time, an additional time allowed in exceptional cases as mentioned above, a demurrage charge of $2.00 a day is assessed for each of the first four days and $5.00 for each succeeding day.

Computing Time.—In computing time, Sundays and Legal Holidays (National, State and Municipal) but not half holidays will be excluded. When a holiday falls on Sunday the following Monday will be excluded. On cars held for unloading, time will be computed from the first 7 a. m. after placement on public delivery tracks and after the day on which notice of arrival is sent or given to consignee. On cars delivered on other than public delivery tracks (private side tracks), time will be computed from the first 7 a. m. after actual or constructive placement on such track. "Actual placement" is made when a car is placed at an accessible position for loading or at a point on side track previously designated by the consignee. If such placing is prevented from any cause attributable to the consignee and car is placed on the private side track serving the consignee, it shall be considered constructively placed without notice.

Notice of Arrival.—Carrier's tariffs provide that notice of arrival shall be sent or given the consignee by the railroad agent in writing, or, in lieu thereof, as otherwise agreed to in writing by the railroad and consignee, within 24 hours after the arrival of the car at destination, such notice to contain car initials and number, point of shipment, contents, etc. When the address of the consignee does not appear on the billing, and it is not known, notice of arrival must be deposited in U. S. Mail enclosed in stamped envelope bearing return address and same must be preserved on file by the railroad company if returned.

Constructive Placement.—When delivery of a car consigned to private spur track cannot be made on account of the inability of the consignee to receive it (track full of loads) or because of any other condition attributable to the consignee, such car will be held at destination, or, if it cannot be accommodated there, at the nearest available hold point, and written notice that the car is held, and that the railroad is unable to deliver will be sent or given consignee. This notice is considered "constructive placement" and in cases where this notice has been given, demurrage will be assessed even though car is not actually placed on the side track.

Average Agreement.—The purpose of average agreement is to permit the shipper to use the day he has earned by unloading his car in 24 hours as an offset on the car he does not unload within 48 hours or two-day period. In other words, when he unloads a car within 24 hours, or one day, he obtains a credit of one day to apply on a car that is not unloaded within 48 hours. Obviously, the opportunity to earn credits by means of which they may escape demurrage charges is attractive to shippers. It is an incentive offered by the carriers to obtain prompt return of equipment.

Under the average agreement, one credit will be allowed for each car released within the first 24 hours of free time. After the expiration of 48 hours' free time, one debit per day or fraction of day is charged for each of the first four days. In no case is more than one credit allowed on any one car and in no case can more than four credits be applied in cancellation of debits accruing on any one car. When a car has accrued four debits, a charge of $5.00 per day or fraction of a day will be made for all subsequent detention and will apply on all subsequent Sundays or legal holidays, including a Sunday or holiday immediately following the day on which the four debits began to run. At the end of the calendar month, the total number of credits will be deducted from the number of debits and $2.00 per debit will be charged for the remainder. When credits equal or exceed the debits, no charge will be made for the detention of the cars and no payment will be made by the railroad on account of such excess of credits, nor will credits in excess of the debits of any one month be considered in computing the average detention for another month. Parties entering into the average agreement are not entitled to allowances for additional free time on account of weather interference, bunching, etc.

Beware of Average Agreement.—From the standpoint of the contractors, the average agreement is not always an advantage. No contractor should enter into the agreement merely because of its credit features. Under some circumstances the charges under the average agreements are much greater than they would be without the agreement. When one enters into the average agreement he waives practically all allowance of additional time for weather conditions, interference, bunching, etc., and further, under the average agreement, after a car has been on the track for six days, a charge of $5.00 is made for every day or fraction thereof, including Sundays and holidays. Only one credit can be earned on each car, and such credits as are earned can only be used in offsetting demurrage on cars that have not been detained more than six days, including the 48 hours' free time. In cases where contractors get up against weather interference, or some other condition where it is impossible for them to unload shipments as received, very often an accumulation of 40 to 50 cars will occur and ten days to two weeks may elapse before the accumulation can be cleared up. Where such accumulation occurs the charges under the average agreement are greatly in excess of what they would be without the agreement, for this reason, that without the agreement the contractor may be entitled to some allowances for bunching, weather interference, etc., and allowance for Sundays and holidays. When 40 to 50 cars are subject to a $5.00 a day penalty an allowance of a Sunday or a legal holiday is a considerable item and the $5.00 penalties for one or two days would amount to more than all the credit that might possibly be earned in a season's work.

Check Demurrage Bills Before Paying.—Demurrage charges are penalties and carriers, in order to collect these penalties, must live up to the exact wording of their tariffs. This tends to make demurrage a very technical proposition and no contractor should pay any large demurrage bill without having it first checked over by a demurrage expert. If the bill is paid and you afterwards learn that you have paid them too much, it is a very difficult matter to secure any reparation. It is better to thrash this matter out thoroughly before the demurrage bill is paid.

Liability on Highway and Paving Contractors for Bills of Defaulting Sub-Contractors

Notes on Procedure Given in Bulletin, Ohio Contractors Association

By CHARLES H. DUNCAN
Secretary Ohio Contractors Association

THE liability under the law of Ohio of a highway or paving contractor for the unpaid bills of a defaulting sub-contractor presents an interesting question. So many inquiries relating to this subject have come to this office that I have endeavored to work out a concise statement in plain language covering the proposition in question. It will be necessary in this memorandum to use some legal terms and phrases, but an effort has been made to put the statement in language which will be intelligible to the layman. In the absence of court decisions covering many phases of the situation, the most that can be ventured in an opinion which may or may not be correct. No question involved in the discussion can be considered as settled until it has been squarely passed upon and decided by the Supreme Court of the state. Many of the questions involved have not been so adjudicated.

In a general way the common law of England is the basis of the law of Ohio. Many of the provisions of the common law have been modified or repealed by statute, and, generally speaking, the rights and liabilities of persons under the present Ohio law are therefore of two classes, to-wit: such as existed at common law, and such as have been set up in our constitution or created by statute enacted by the legislature of the state. The former class are known as common law rights and liabilities, and the latter are denominated constitutional or statutory.

Rights Believed to Be Statutory.—It is believed that all of the rights which exist in Ohio against a highway or paving contractor and in favor of the creditors of a defaulting sub-contractor are statutory in character. In other words, it would seem that if the statute law of the state on this subject were blotted out, the creditors of a defaulting sub-contractor on highway or street work would not possess any rights against the principal contractor merely by reason of his being the principal contractor. Unfortunately for the principal contractor, however, there is a considerable body of statute law on this subject. Rights which the creditors of a defaulting sub-contractor may acquire and enforce against the principal contractor arise in two ways, to-wit: (1) under the bond furnished by the principal contractor, or (2) under the mechanic's lien law of the state.

Liability Under the Bond.—The liability arising under the bond will be first discussed. This liability is created and defined by Sections 2365-1 to 2365-4 inclusive of the General Code. Briefly speaking, these sections provide that the contractor and his surety shall be liable on the bond for the payment by the contractor, and by all sub-contractors, for all labor performed or materials furnished in the work covered by the bond. These provisions apply not only to roads and streets, but also to all other public works or improvements carried forward by the state, or any county, city, village, township or school district thereof. Under the above provisions it may safely be asserted that the principal contractor on a highway or street, and the surety on his bond, are liable on the bond for the payment of all unpaid labor and material bills contracted by a sub-contractor on the work.

In the absence of express statutory definition or pronouncement from any court, it would be unsafe to attempt an exact definition of the word "labor" used in the above statutory provision. In the case of Combs v. Jackson, 69 Minn. 336, the word "labor" similarly used was held to include the labor at a quarry where the contractor agreed to get out and furnish stone, even though the laborers did not know the structural destination of such stone. In the case of Friedman v. Hampden County, 204 Mass. 494, the wages of a watchman employed to guard material at the side of the work were held to be covered by the bond. A similar conclusion was reached with respect to wages due to a blacksmith engaged in sharpening tools in the case of French v. Powell, 135 Cal. 636. It is safe to assume that the courts would be inclined to be extremely liberal in extending protection under this provision, and that the term "labor" used in Section 2365-1 G. C. would be liberally construed so as to make the contractor and the surety on his bond liable for the payment on all bills incurred and unpaid by any sub-contractor, and which might reasonably be said to represent labor performed on or about the work or in general connection with the construction thereof. If you employ a sub-contractor on public work in Ohio, and this sub-contractor defaults, leaving unpaid labor bills incurred in connection with his sub-contract, you may safely assume that you and your surety are liable for the payment of such bills.

Materials Furnished.—The term "materials furnished" used in the above statute undoubtedly extends to all materials delivered to a sub-contractor and by him incorporated in the work. If you enter into a sub-contract with any person in Ohio to do part of the work on a road or street, and your sub-contractor purchases such articles as stone, gravel, sand, brick, cement, asphalt, steel, etc., for use in performing his sub-contract, and the sub-contractor so uses such materials and fails to pay therefor, you can safely assume that you and the surety on your bond are liable for the payment of the bills in question. The courts of another state following an Ohio decision under a statute different from that now in force have gone so far as to hold that materials furnished under a public contract suitable for the work to be performed and delivered at the site, will justify recovery on the bond without showing that they actually were used in the construction. See Red Wing Sewer Pipe Company v. Donnelly, 102 Minn. 192. The Ohio case of Standard Oil Company v. Detroit Fidelity and Surety Company hereinafter discussed is in apparent conflict with the Minnesota case, but the conflict is more apparent than real.

The courts of several states other than Ohio have held the following to be "materials" within the meaning of statutes similar to the one in Ohio; explosives used in blasting, coal consumed as fuel for equipment, and other similar articles consumed rather than incorporated in the work. In view of the recent Ohio case of Standard Oil Company v. Detroit Fidelity and Surety Company, above referred to and which was decided by the Court of Appeals of Cuyahoga County, February 7, 1927, 24 Ohio App. 108, and which is reported in the Ohio Law Bulletin and Reporter of Aug. 8, 1927, it is extremely doubtful whether the Ohio courts would extend the bond provision relating to materials to include any articles other than those materials actually suitable for and designed for incorporation in the work, the necessity of showing actual incorporation also being a possibility. In the case last mentioned above, the court held that gasoline and oil furnished to operate motor trucks carrying material for highway construction and purchased

by a highway contractor are not covered by Section 2365-1 of the General Code, and that the cost of the same cannot be recovered in a suit on the bond. The court expressly held that the word "materials" used in the statute includes only material used in construction in a physical sense and which actually and physically becomes a composite part of the improvement itself. As hereinafter noted, it is possible that this observation is not to be taken literally, and that the same must be interpreted in connection with the exact question before the court.

In like manner the Supreme Court, in the case of Royal Indemnity Company v. The Day and Maddock Company, 114 O. S. 58, decided Feb. 2, 1926, held, in reversing the Court of Appeals of Cuyahoga County, that there is no liability on the bond of a public works contractor for the rental of equipment or machinery used in the performance of a contract. The questions which I am now discussing have given the courts much trouble, as is well evidenced by the case last cited. The Court of Appeals of Cuyahoga County reversed the Municipal Court of Cleveland, and was in turn reversed by the Supreme Court in an opinion concurred in by all the judges participating in the hearing of the case. This would probably be a good place to observe that my opinions herein expressed are based on the decisions of the courts to date. A new decision on some phase of the situation not already passed upon by the courts or a reversal of some lower court decision by the Supreme Court may at any time require a restatement of some of the conclusions herein expressed.

Mixed Claims.—Questions will arise which are not easy of solution, by reason of the fact, that the claims may be said to be "mixed." By way of illustration, a sub-contractor employs the owner of a truck to himself drive his truck and to furnish the gasoline and oil thereof. If only the wages of the truck driver were involved, the bond would be liable. If only truck rental or oil and gasoline were involved, the bond would not be liable. What is the answer where the wages of the truck driver, and either the rental of the truck or the gasoline and oil used, or both, are involved, and the contract between the sub-contractor and the owner and driver of the truck sets up no division of the compensation among these several items? The courts would certainly strain a point to protect the owner and driver of the truck to the extent of what might be fairly regarded as adequate wages for the time employed. The courts could do this by taking evidence and dividing the claim, or they might hold that since labor and rental of equipment, etc., were confused, the whole claim ought to be recoverable on the bond.

It will be noted that Section 2365-1 of the General Code makes no distinction between the unpaid labor and material bills of the principal contractor and those of a sub-contractor. The principal contractor and his surety on the construction bond furnished under the statute are therefore liable on such bond for the payment of the unpaid labor and material bills of a defaulting sub-contractor. As before observed, the word "labor" used in this sense has not been defined by the courts of Ohio, but would probably be given a broad significance. The term "materials" so used has been defined in the recent case above cited as limited "to materials which actually and physically become a composite part of the improvement itself." Gasoline and oil, coal, explosives, and other similar items would not be "materials" within this definition, and the principal contractor and his surety would not be liable on the bond for the unpaid bills of a sub-contractor incurred for such articles. If the Cuyahoga County opinion is taken literally, it would be necessary in order to recover on the bond for such articles as gravel, stone, brick, cement, etc., to show that such materials actually were used in the construction. This is in accordance with the express declaration of the court in its opinion, which opinion seems in conflict with State ex rel. v. Watts, 100 O. S. 380, and yet this exact question was not before the court, and if it had been I doubt whether the court would have so held. As before pointed out, the courts of at least one other state have reached a different conclusion, holding that if the materials were suitable for the work performed and were delivered at the site, it was not necessary in a suit upon the bond to show that such materials were actually used in the construction. An Ohio court might reach a similar conclusion, if the same question were squarely presented. The language used by the Cuyahoga County court was intended as an answer to an entirely different question.

It remains only to add that in order to hold the principal contractor and his surety on the bond, the creditors of a defaulting sub-contractor must proceed as provided in the statute. They must at any time after performing such labor or furnishing such materials, but not later than ninety days after the acceptances of the work, furnish the sureties on the bond a statement of the amount due. No suit shall be brought on said bond until after sixty days after the furnishing of said statement, but any action brought must be commenced not later than one year from the date of acceptance of the work.

All of the observations already made relate to the liability of the principal contractor and his surety on the so-called construction bond, and are therefore equally applicable to state, county, city and village work.

Liability Under Mechanic's Lien Statute.—It remains to discuss the liability of a principal contractor for the unpaid bills of a defaulting sub-contractor under the mechanic's liens statutes of the state. The mechanic's liens statutes apply on county, city and village work. If Hon. John G. Price, Attorney General of Ohio, was correct in an opinion rendered by him on Jan. 4, 1923, o Hon. Robert S. Parks, Prosecuting Attorney of Geauga County, the mechanic's lien statutes do not apply on state highway work. Mr. Price held in his opinion that by reason of the amendment of Section 1208 G. C. in 109 O. L. 159, contracts entered into by the state under the state aid highway laws subsequent to the going into effect of said amendment were not subject to lien under the provisions of Sections 8324 to 8331 inclusive of the General Code or otherwise, either as to funds in the state treasury or in the county treasury applicable to such contracts. Acting on this opinion, the Department of Highways of Ohio has refused to receive or recognize mechanic's liens against state highway funds in the state treasury. As to such state funds, it would seem that the courts must affirm Attorney General Price's ruling, if the same is ever called in question. There might be more of an argument as to county funds certified for use on a state highway contract. However, present advices must be grounded on the best authority available, and basing the same on such opinion, the statement must be made that the mechanic's lien statutes apply only to county, city and village work, and do not apply to state highway work, either as to state or as to county funds.

Section 8324 of the General Code provides among other things that any sub-contractor, material man, laborer or mechanic who has performed labor or furnished material, fuel or machinery, or is performing labor or furnishing material, fuel or machinery, or is about to perform labor or furnish material, fuel or machinery for the construction or repair of any road or street, may at any time within four months from the performance of the labor or the delivery of the machinery, fuel or material, file with the officer or board constructing the improvement, a sworn and itemized statement of the amount due, and upon receipt of such notice it is required by the succeeding section of the General Code that the public official constructing the improvement shall "detain in his hands all subsequent payments from the principal or sub-contractor to secure such claims, and the claims and estimates of other sub-contractors, material men, laborers, mechanics or persons furnishing materials to or performing labor for any contractor or sub-contractor who intervene before the next subsequent payment under the contract or within ten days thereafter," whatever this means. For the purpose of giving notice to others, interested claimants under this statute are required by Sec-

tion 8326 G. C. to file a copy of their notice with the recorder of the county. If, however, the claimant does not file this copy with the recorder, he still retains his lien, and all that he loses is his preference over other claimants. If, after a copy is filed with the recorder, other claimants do not file their claim within the time fixed, it seems that under the statute they lose their recourse against the fund in the hands of the board or officer constructing the improvement. The public authority shall, and the lien claimant may, furnish the principal contractor with a copy of the notice within five days. If the principal contractor desires to dispute the claim, he must within five days notify the public authority in writing of his intention to dispute the same. If he does not file this notice, he shall be considered as assenting to the correctness of the claim.

Other pertinent provisions are found in Section 8324 of the General Code and the subsequent sections.

These statutes are in anything but a satisfactory shape. Their provisions are confusing, contradictory and "half baked," and represent the acme of poor English. It seems clear, however, that whatever rights the unpaid creditors of a defaulting sub-contractor may have to obtain a lien, such rights extend equally to labor expended on the work, material furnished for the work whether actually incorporated therein or not, fuel which undoubtedly would be construed to include not only coal but also gasoline, and also the rental of machinery and equipment furnished. It will also be found in actual practice that county and municipal authorities, in order to be on the safe side of the question and to avoid the danger of being called to account for making payment to the principal contractor when not authorized to do so, will decide all questions upon which there might be any argument in favor of the lien claimant and against the principal contractor. It is fair to assume therefore that the principal contractor upon road and street work which is being built for a county or municipal corporation may be held for the unpaid bills of a defaulting sub-contractor for labor, materials, fuel, including gasoline, and also the rental of machinery and equipment, provided the claimants act within four months from the date of the performance of such labor or of the furnishing of such material, fuel or machinery, and before the county or municipality has settled with the principal contractor in full, and provided further that the claimants proceed in substantial compliance with Section 8324 G. C., and the succeeding sections, with the further proviso that all close questions, and some questions not so close, will probably be decided by the public authorities against the principal contractor and in favor of the lien claimant. These sections of the General Code have been a part of the law of Ohio for many years. They represent the old-time and successful efforts of material and machinery supply houses to pass the functions of their credit and collection departments over to the public officials. A contractor whose funds are tied up by liens for disputed items will ordinarily be forced to hire an attorney and start a suit to marshal liens and determine their correctness and priority.

How Can Contractor Protect Himself.—The question arises, in conclusion, as to how a highway or paving contractor can protect himself against the operations of a dishonest or unreliable sub-contractor. The real answer to this question lies in the statement that there is no sure way of obtaining such protection. If you deal with dishonest or financially irresponsible people, you can reduce the chances of loss by such expedients as requiring a bond, holding up a percentage of the amount earned, supervising the payment of your sub-contractor's bills, and other similar methods, but eventually these methods will fail and you will have to take a loss. You cannot expect to deal with such people over a period of years and escape all loss. You will eventually find yourself in a position where you will be compelled to pay some of the bills of your irresponsible sub-contractor with your own money, and the chances of taking a substantial loss cannot in the light of experience be said to be remote. A clear and well understood verbal contract without bond or other safeguard, made with an honest and competent sub-contractor who knows his business and has adequate financial means, presents a negligible chance for loss when compared with a contract made with a dishonest or irresponsible contractor and supposedly protected by a bond, a provision for a retained percentage, supervision of the expenditures of the sub-contractor, and any and all other safeguards that may be invented or devised.

Suggested Precautions.—If you are compelled to deal with sub-contractors, or feel that you must prosecute your work, or any part thereof, through sub-contractors, the following precautions are suggested. There should be a clear and explicit written contract setting forth all of the terms of the agreement. This contract should be guaranteed by a bond which should be executed by a responsible surety company, or by at least two private sureties of unquestioned financial worth. Both the contract and the bond should expressly provide for and guarantee the payment of all bills and claims of the sub-contractor of every kind and description growing out of his execution of the work. There should be a provision for a reasonable retained percentage and unless the sub-contractor is of known adequate financial worth, he should be required by the terms of the contract to present satisfactory written evidence that all his bills incurred in connection with the work up to the time of payment to him have been met, or there should be a provision by which such bills are approved by him and direct payment made to the holders thereof by the principal contractor. The sub-contractor should be investigated, and absolutely no dealings had with those reputed to be dishonest or irresponsible. The experience of this office during the past nine years would furnish enough material for a large volume on the distressing results of dealing with dishonest and irresponsible sub-contractors. It is also true that in many of the cases brought to the attention of this office the principal contractor sought to protect himself and took steps along that line which to him seemed adequate. It must therefore be repeated in conclusion that there is but one way to obtain protection against a dishonest or irresponsible sub-contractor, and that is by refusing to enter into any relations of any kind or description with such an individual.

Indiana Ranger One Ton Model

The latest addition to the complete line of motor trucks manufactured by the Indiana Truck Corporation, of Marion, Indiana, is the new one ton, six cylinder chassis, known as Indiana Ranger—Model 200. This model is in large production at the Indiana plant and there is a big demand from the company's branches and distributors all over the country for this new chassis.

The Indiana Ranger is powered with a six cylinder, valve-in-head engine, 3¼ in. bore by 4¼ in. stroke. It has a piston displacement of 211.5 cubic inches and develops 45 brake horsepower. Mechanical four wheel brakes of the internal expanding type are standard equipment on this model. The wheelbase length is 137 in.

The engine, clutch, transmission, propeller shaft, front and rear axles, steering gear, frame, springs and wheels are all truck units with truck engineering and construction throughout.

The patented "Tors-Elim" 3-point mounting of cab, motor and radiator units, exclusive to Indiana Trucks, is used on this Indiana Ranger chasis. This mounting prolongs the life of the truck and adds to its easy riding qualities. The radiator, hood, cowl and cab maintain their position substantially as a single unit, independent of the chassis, and free from torsional strains and vibration.

Standard equipment on the Indiana Ranger chassis includes Moto-Meter, full crown front and rear fenders with running boards, nickel plated bumper. hub caps and radiator shell, electric starting and lighting equipment, air cleaners, oil filtrator, speedometer and tire carrier.

Moving Gary Sand With an Elevating Grader

Even sand, always a hard proposition for earth handling contractors to do anything with, has at last had to give way before modern time and labor-saving equipment.

Gary, Ind., is noted almost as much for its sandy soil as it is for the steel it produces. It's that very fine stuff that sifts through and blows around every bulkhead or container used in an effort to restrain its natural desire for travel. Nowhere could more perfect conditions have been found for imposing the severest tests on earth handling equipment.

William Hillmer, a contractor on subdivision work in Gary, was recently faced with the problem of cutting a street through a sand dune and filling in another stretch about ½ mile away. He decided on an Austin Contractor's Special New Era elevating grader with power take-off and the Western 7-yd. crawler dump wagons to handle this difficult set up. Caterpillar tractors were used to pull the grader and each of the crawler wagons.

With the power take-off, the elevator is driven directly from the tractor motor, and it makes no difference how much traction the rear wheels of the grader have. This is stated to be the first time on record that an elevating grader was used successfully in the Gary sand. The results attained certainly justified its use on Mr. Hillmer's job, and point the way to lowered costs on all work of a similar nature.

The Western crawler wagons with their 7-yd. capacity, are stated to have actually carried more than five times as much as ordinary horse drawn wagons. Moving through the soft sand on their broad Athey truss wheels, they were handled without difficulty by the caterpillar tractors, and because of their traveling and turning speeds, were able to keep the grader working to capacity.

With the speed of operation greatly increased and the operating crew reduced to four men, the possible savings are readily seen, especially when the cost is compared with that of doing the same work with scrapers, which heretofore have been about all that could be used on such operations.

Street Through a Sand Dune at Gary, Ind., with an Elevating Grader

Link-Belt Announces a New 2-Yard Shovel

Indicative of the trend toward the more powerful, greater capacity machine is the announcement by Link-Belt Company, of Chicago, Indianapolis and Philadelphia, of the addition of a full 2-yard capacity machine to their line of crawler cranes, shovels and draglines. Heretofore the largest capacity machine built by this company was a 1½-yard unit.

The Link-Belt K-55, as the new machine is known, is a powerful, heavy duty, all-purpose, 2-yard machine, primarily designed for use as a shovel with 30 ft. boom and 18 ft. dipper stick carrying a 2-yard struck-measure-capacity all-manganese-steel dipper, as a dragline to handle 2-yard dragline bucket, for medium and medium-heavy excavating, on boom 50 ft. long; or a 1½-yard dragline bucket on boom 60 ft. long; as a clamshell bucket crane of 2-yard capacity, for sand, gravel or materials of equal weight per cubic foot, and consistency, on boom 50 ft. long; or a 1½-yard bucket, in such materials on boom 60 ft. long; or, of course, an equivalent weight of loaded bucket in heavier or lighter materials; or as a trench shovel of 2-yard capacity.

All attachments are interchangeable without removing or disturbing the mechanism of the machine proper.

While there is a large field for the K-55 in quarries; large sand and gravel operations; on unloading docks; in drainage work; and many other places where large production is required, a special clearance reducing arrangement contributes to making the machine a particularly convenient one for the contractor, by making it possible to ship it from place to place without dismantling, thus saving hundreds, and often thousands, of dollars, and many days times, every time the machine is shipped to a job.

Incidentally, this is the only machine of, or near, its capacity which does not require extensive dismantling and preparation for shipment, the manufacturers claim. The K-55 has a collapsible mast, and special shipping treads which may be quickly and easily substituted for the working treads, to bring the machine within the railroad clearance requirements of 10 ft. 4 in. overall width and 16 ft. 0 in. overall height above top of rail when loaded on flat car.

Besides the unit cast steel construction of lower and upper frames; self-cleaning crawler treads and large bronze-bushed crawler rollers; enclosed cut gearing and bronze-bushed bearings throughout—features which Link-Belt Company has pioneered since they first began to build crawlers, other details of construction which are outstanding and indicative of the caliber of the new machine, include:

Internal expanding friction clutches of unusual size and power, the main drum clutches being 42 in. in diameter; and swing and travel clutches, 30 in. diameter.

A 13½ in. diameter center pin, adjustable from above, which can be removed as a unit with the vertical travel shaft assembly, without removing any other parts.

Large drums with renewable cast steel shells, having air space between clutch and brake surfaces, for rapid cooling; and large, powerful drum brakes, 48 in. diameter by 5 in. wide.

The machine in working condition is 12 ft. wide overall at the lower frame, which gives it ample stability for the work for which it is designed. Crawler treads are 36 in. wide.

The K-55 is built to be driven with gasoline engine, electric motor or Diesel Engine drive.

State Highway Work in Arizona.—The final budget of the state highway department for road work during the fiscal year 1928-29 has been adopted by the state highway commission and amounts to $8,198,299. This will be divided into $4,697,103 for new construction, $2,813,481 for maintenance, and $687,713 for overhead expenses of the department.

Manufacturer Speeds Service By Airplane

The world moves. Times change. Business progresses. Markets considered inaccessible 15 years ago are today readily reached by the automobile and improved roads. And now we have the airplane, bringing the two coasts closer together by hours. Commercial aviation has come into its own. Of especial interest to the construction field, then, will be the announcement that the first to adopt the airplane as a member of its sales department is the Iowa Manufacturing Co., of Cedar Rapids, manufacturers of the well-known Cedar Rapids Crusher, One-Piece Portable Crushing Outfits, and other rock, sand and gravel equipment. According to the company officials, the primary reason for purchasing this plane was the desire to give its field representatives the co-operation and immediate backing where and when most needed in their contacts with the highway field.

The plane purchased by this concern is a six place Stinson-Detroiter Monoplane, the same as that used by Brock and Schlee in their record-breaking flight almost around the globe. It is the same type of plane as used by Capt. George Wilton in his North Pole flight; by Ruth Elder and George Haldeman in their trans-Atlantic flight.

It is a six-passenger, dual control, cabin type monoplane, powered with the famous nine cylinder Wright Whirlwind motor, capable of developing 200 H.P., and boasts the finest equipment for safety and beauty of design available.

An 85 gallon gasoline tank gives it a cruising radius of from 750 to 1,000 miles. Six individual padded wicker seats, heating and ventilating devices, and a full vision cabin provide the utmost in comfort for passengers. It makes a top speed of 128 miles an hour and a cruising speed of 107 miles an hour, has a wing spread of 47 feet, and is 28 feet long.

Weighing approximately 1,800 lbs., the ship will carry more than its own weight. A toilet compartment with wash stand and other necessary equipment provides for the additional comfort of passengers on long distance flights.

The utmost in safety has been provided by means of a complete set of instruments with the exception of an earth inductor compass. An additional turn and bank indicator has also been added to the equipment, enabling the aviator flying at night or in a heavy fog to prevent turning on his side or going into a side slip. It is as nearly fool-proof as any ship can be.

The traditional "stick" used in most airplanes has been done away with in the Stinson-Detroiter. Before the two control seats at the front of the cabin are two wheels not unlike the wheels of the ordinary automobile, by means of which the navigating is done. Thus, the ship is either a right or left-hand drive. When visiting various cities, it is understood that highway officials, engineers, and contractors will be given an opportunity to enjoy a ride in this plane by invitation.

This Plane Will Keep Iowa Mfg. Co. Officials in Closer Touch with the Field

Hydraulic Controlled Grader Easy to Operate

The Scottdale caterpillar drive hydraulic controlled grader is said to be extremely easy and positive to operate and to be strictly a one-man machine. Powered with the McCormick-Deering tractor, this machine has been designed for maintenance of roads where a grader of this type is useful, and has the advantage of requiring no hard work on the part of the operator. Practically no physical effort is needed, except for the actual operation of the tractor and the use of the steering wheel, since the actual operation of the grader is done through hydraulic controls, requiring simply the slight shifting of an easily worked lever.

Steering is accomplished through a head type worm and worm gear steering gear with roller bearing thrust at each end of the worm. An independent scarifier is included, hydraulically operated and easily adjustable. The reinforced mold-board is adjustable sideways. The bade is completely controlled by one lever in such a way that the ends may be elevated to any adjustment separately or simultaneously with one hand as desired. The frame is strongly made of 7 in. 17½ lb. I beam sections. All control is from a central location and control is very simple, it is said. A heavy front casting is installed to hold down the front end. Roller bearings have been installed wherever appropriate, and special attention has been given to lubrication, using the Alemite system.

This grader is manufactured by the Marion Machine, Foundry & Supply Co., of Marion, Ind., at Scottdale, Pa.

Curing Concrete Pavement Without Water or Dirt

A new method of curing concrete pavement that has recently come into extensive use in California and other western states, consists of the application with a spray gun of a bituminous paint immediately after the concrete pavement has been poured and belted. The principle of the method is that there is sufficient moisture in newly poured concrete to effect a perfect cure if the moisture can be kept from evaporating. The bituminous paint is claimed to completely seal the surface of the concrete and prevent the evaporation of the original mixing water. This method eliminates all use of earth and water, burlap, sprinkling or straw. It is further claimed that it permits the use of the street or highway by pedestrians within 2 days after the concrete is laid; by light automobiles within 7 days and by heavy traffic within 12 days. This method of curing is known as the Hunt Process, and the coating applied is known as the McEverlast Paving Special. This is composed chiefly of "processed" Trinidad Lake asphalt, Bermudez asphalt and Gilsonite blended at an extremely high temperature. It is used cold and applied without artificial heat. Over 15,000,000 sq. ft. of concrete pavement had been cured by the Hunt Process up to June 1, 1928, and contracts for curing an additional 10,000,000 sq. ft. had been signed. The Hunt Process was developed by, and is being handled by the Everlasting Paint and Sales Co., Los Angeles, Calif.

Depreciation on Road Builders' Equipment.—The United States Treasury Department has requested the American Road Builders' Association to cooperate in making recommendations covering depreciation of road building equipment and a committee from the A. R. B. A. has been appointed to work on the problem. The Associated General Contratcors of America has carried on extensive research on this subject and the suggestion has been made that the A. R. B. A. committee meet jointly with the A. G. C. of A. committee to agree upon the same recommendations in connection with proper charge-offs for equipment depreciation.

New Portable Gravel Plants

An important factor in the economical construction and maintenance of roads today is the development of local rock and gravel deposits. The Austin-Western Road Machinery Co. has recently brought out portable crushing and screening plants that are adaptable for service under all conditions because of the flexibility of the separate units, and this equipment has been especially designed for use in the development of these aggregate pits.

Nearly every locality in the country has within its limits deposits of stone or gravel, or quantities of roadside stone that are usable for road purposes. Knowing that local conditions vary so greatly that few plants can be set up in exactly the same way, Austin-Western has designed elevators, screens, bins, feeding conveyors and crushers that combine to make completely portable plants, whether purchased together or separately.

Austin portable gravel screening and crushing plants are built for use with 100-type Austin Gyratory Crushers. A typical plant consists of a 50-ft. portable conveyor, 12-ft. revolving screen, 15-yd., two-compartment portable steel bin and No. 104 Austin Portable Gyratory Crusher, with folding elevator. The operation, as described by the manufacturer, is as follows: The conveyor brings the gravel in the revolving screen which has 4 ft. of ½-in. perforations to take out the sand, and 8 ft. of 1-in. performations. The oversized material passes out the end of the screen and down a chute to the crusher. After being crushed, it is returned to the screen again, and a grizzly spout diverts the stone chips to the second compartment of the bin instead of permitting them to drop through the first screen section into the sand.

The Western Road Metal Plant, another of these outfits, is completely portable and recommended for reducing all sizes of gravel to a designated maximum, such as 1-in. Crusher, screen and return elevator are mounted on the same truck.

The Western Aurora Jaw Crusher is used with Western Road Metal Plants. The two-blow stroke delivered by this crusher is said to increase production, eliminate vibration and save power. The hourly capacity ranges from 5 to 25 tons, depending upon the size of crusher used, say the manufacturers. The gravel is brought to the screen by a portable conveyor. Either the shaker type of screen, or a double rotary screen may be used.

The material smaller than the designated maximum—which in most localities is now 1-in.—drops through the screen and is transported directly to the bin. The oversized material passes out the end of the screen into the crusher, and after being crushed is brought back to the screen by the return elevators.

If it is desired to remove the sand, a very efficient device for either type of screen can be supplied, which takes out the sand immediately, and diverts it to a separate delivery conveyor. Delivery of the finished product from plant to bin is made either by a bucket type of elevator or a belt conveyor.

One-course gravel roads are becoming increasingly popular, and this type of plant has been particularly designed to produce material for such roads.

Pickering Governor Now Built for Tractors

Pickering governors, for many years standard equipment for steam equipment, are now available for Fordson, McCormick-Deering, Hart-Parr, Twin City, and other comomnly used makes of tractors. Retaining the spring-principle head, this unit operates through a positive drive and does not retard fuel flow, according to the manufacturers. The purpose of the governor is to provide a steady flow of power at all times by adapting engine speed to load automatically, thus avoiding possibility of stalling when the tractor is suddenly subjected to overload, and to provide more ecomonical operation by this adaptation of the power to the load. Important fuel savings have been reported. Due to the avoidance of racing of the engine, repairs are minimized, according to the manufacturer.

On some tractors, this governor is installed in place of the governor regularly supplied by the manufacturer of the tractor, while in others the old governor is simply disconnected and the new one mounted in a different manner. In any case, the governor is supplied complete and ready for installation, and can easily be mounted and put into service in about an hour by any man familiar with the tractor and handy with tools.

These governors, that are said to radically improve the service and increase the efficiency and economy of the tractor, are manufactured by the Pickering Governor Company, Portland, Conn.

New Pickering Governor for Tractors

Safety Record Set by Cement Industry

Reducing lost time accidents by 20 per cent the portland cement industry finished its June No-Accident Drive with 47 mishaps and only one fatality. For a similar period last year 59 accidents reported with one fatality. During June, 1926, 198 lost time accidents were suffered by the industry with six fatalities.

These results are even more important when it is taken into consideration more men were employed and more plants in operation during the past month than in June, 1927. Last year 145 complete plants entered the June drive against accidents, during this June 162 plants fought to eliminate personal injury mishaps. Twenty per cent less accidents were recorded with 11 per cent more mills reporting.

One hundred and thirty-eight safety banners out of the 162 hoisted on the plant flag poles are still flying. These flags were presented to the plants by the Portland Cement Association with the understanding that they were to fly as long as no lost time accidents occurred. In case of an accident the mill flag was sent back to the Association with an explanation of the mishap that caused its loss. Only 24 mills lost their flags during the entire 30 day period.

Nearly 50,000 cement workers participated in the June No-Accident Drive. Each man signed a card pledging himself to be careful during the month and to protect and help others. Not only did the workers pledge against accidents but every foreman, superintendent and executive enrolled in the campaign.

So much interest was aroused by this year's drive that the mill employes have already started a drive during July to beat the June record.